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Final Environmental and Socioeconomic Impact Report

The M.B.T.A. Fare Increase

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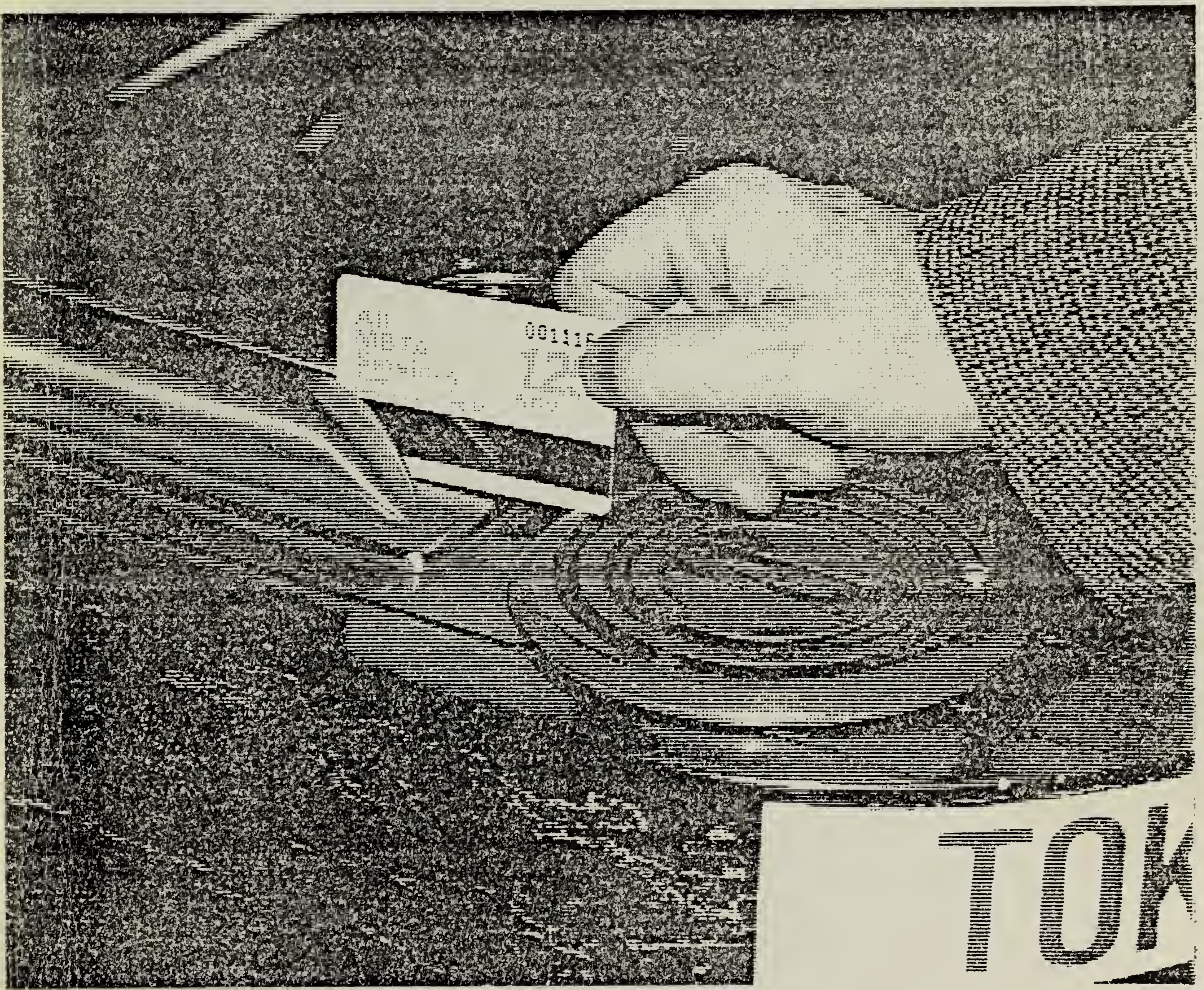

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FINAL
ENVIRONMENTAL AND SOCIOECONOMIC IMPACT REPORT OF THE MBTA FARE INCREASE

December 1983

This document was prepared by **CENTRAL TRANSPORTATION PLANNING STAFF**, an interagency transportation planning staff created and directed by the Metropolitan Planning Organization, consisting of the member agencies.

Executive Office of Transportation and Construction
Massachusetts Bay Transportation Authority
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PREPARED FOR THE BENEFIT AND USE OF THE MUNICIPALITIES CONSTITUTING THE BOSTON METROPOLITAN AREA PLANNING DISTRICT

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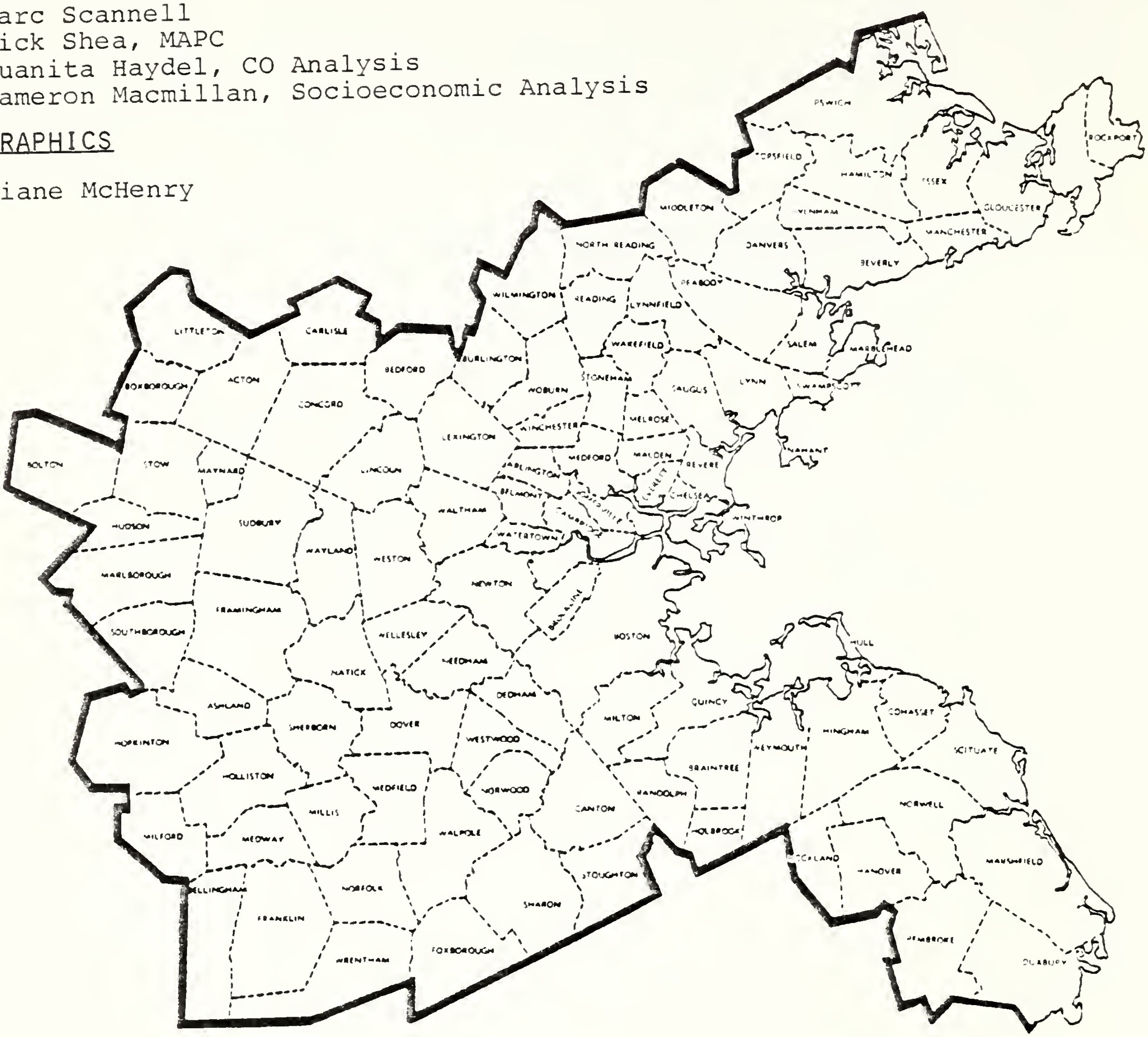

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1.0 INTRODUCTION

AN OVERVIEW OF THE REPORT

This report presents a description and analysis of the impacts associated with a 1981 fare increase on the rapid transit and bus lines operated by the Massachusetts Bay Transportation Authority (MBTA). Both the environmental and socioeconomic impacts are presented in this report.

Section 1 is a summary of the report. It includes the background financial conditions which required that action be taken, the alternatives examined, the anticipated environmental and socioeconomic impact of the chosen alternative (a fare increase), and information on ridership levels as forecast and as found through the 1981 Fare-Mix Sampling Program.

Section 2 of this report describes the existing system and outlines service cuts and fare changes. Next, this section presents a historical review of ridership and fare levels on the MBTA. Finally, operating costs and funding sources are discussed.

Section 3 presents a review of the impacts of the August 1981 fare increase on ridership. These changes are presented in terms of an elasticity analysis.

Section 4 provides an estimate of the environmental impacts of the recent fare increases. The air quality impacts are analyzed in both a regional and a localized context. Energy impacts are also described.

Alternative fare structures are presented and analyzed in Section 5. Included in the review are such strategies as peak period pricing, reduced rates for transfers, and alternative fare collection techniques.

Section 6 discusses the socioeconomic impacts. Where possible, the impacts are disaggregated to isolate the effects on specific target groups; the impacts are quantified where appropriate. This section has been designed to fulfill the requirements of a Socioeconomic Impact Report and addresses the issues outlined in the scope of work provided by EOEA.

Section 7 is concerned with the mitigating measures aimed at reducing the adverse impacts of fare increases. Changes in fare policy and collection, service and its quality, management, planning, and efficiency are all included. For each, the MBTA level of commitment and a schedule for achievement is provided.

Section 8 examines the short- and long-term outlooks for stabilized fare and service levels at the MBTA and provides suggestions and recommendations for action should future fare changes be necessary.

1.1 SUMMARY OF THE ENVIRONMENTAL AND SOCIOECONOMIC IMPACT REPORT OF THE M.B.T.A. FARE INCREASE

This report presents an analysis of the impacts associated with the 1981 fare increase on the rapid transit and bus lines operated by the Massachusetts Bay Transportation Authority (MBTA). Both the environmental and socioeconomic impacts are presented in this report.

1.1.1 Background

The study was required as part of an agreement between the Executive Office of Environmental Affairs (EOEA) and the MBTA. EOEA permitted the MBTA to increase fares on August 1, 1981, prior to completion of environmental review, provided, among other items, that the MBTA complete an Environmental Impact Report (EIR), a Socioeconomic Impact Report (SEIR), and a Management Practices Study. This report fulfills the requirements for both the EIR and SEIR.

The scope of this report is somewhat unusual in that ordinarily an EIR would contain predictive information on environmental impact in advance of the implementation of the change. Thus, no data on the results of the action usually accompanies the EIR. In this case, however, much of the analysis occurred concurrently with both the fare increase and the subsequent decrease in fare levels. This timing has allowed for some of the new ridership (post-increase) estimates and associated impacts to be derived as the result of a direct fare mix sampling study conducted in November of 1981. Environmental data provided is solely from computer simulation modeling efforts, and does not include any sampling or data collection performed after the increase commenced; however, the results of the 1981 ridership sample were used as model inputs. The study was conducted by the Central Transportation Planning Staff (CTPS) at the request of the MBTA.

1.1.2 The Policy Framework For Managing The MBTA

The MBTA is a transportation operating agency. As such, its primary concern is to maximize ridership while minimizing rises in costs. The following goals, stated in the 1978 Program for Mass Transportation of the MBTA, provide the MBTA management with both overall directional goals and some specific objectives which indicate the achievement of these goals.

Management Goals:

- Increased Riders. To attract additional riders who can be served at reasonable cost in relation to present costs per rider.

- Control of Overall Financial Burden. To bring under control the overall costs of supplying public transportation and to seek an equitable distribution of the resultant financial burden among riders and public revenue sources.

- Improved Quality of Service. To improve the quality of service offered, where this is possible without unreasonable increases in costs per rider.

- Unit Costs and Productivity Improvement. To reduce the cost of supplying a desirable level of public transportation service and to increase the level of service provided at a given expenditure level.

- Improved Safety and Security. To reduce the hazards to which riders and employees are exposed in connection with public transportation service.

- Equitable Fares and Service. To implement a fare structure and fare level which are equitable in terms of price per value received and to apply uniform criteria for the establishment and discontinuation of service.

Social Goals:

The MBTA is also an agency of government. Consequently, it must serve the public in an environment shaped by society's demands as expressed through its elected officials. It should be responsive to at least the following social goals:

- Provision for Riders with Special Needs. To provide transportation service for the elderly and handicapped persons, particularly those who do not have ready access to an automobile.

- Environmental Improvement and Fuel Consumption. To reduce air pollution, noise pollution, other forms of environmental degradation, and fuel consumption associated with supplying public transportation service.

- Equal Opportunity/Affirmative Action. To remedy the effects of any illegal discriminatory practices in the MBTA, to eliminate such practices, and to take positive action so that the MBTA work force reflects the racial and sexual composition of the population where the jobs exist.

- Economic Recovery. To contribute to the reduction of the unemployment rate in Massachusetts and stimulate the depressed economy through a large scale capital investment program.

- Land Use and Development. To contribute to and facilitate the process of land use planning and development for the long term.

Furthermore, the 1978 PMT directly discusses the costs which some goals may entail:

> "It is important to recognize that achievement of social goals may impose costs on the MBTA which are in excess of those associated with a strictly operating efficiency criterion. Investment of resources for social purposes produces returns, but not ones as easily identified as more riders or lower costs. Therefore, a dilemma facing the MBTA and the public will be how to share more equitably the burden of MBTA cost. Within the MBTA's control is the ability to achieve greater efficiency in both operations and construction, in order to stabilize the relationship between fare revenues and operating costs. Yet to be resolved is how the public will choose to share in the increasing costs of the MBTA as a means for achieving social goals."

1.1.3 Transit Finance

The MBTA fare increase of 1981 was implemented in a changing financial environment for mass transportation. The implications of financial pressures created by changing public policy and their impact on transit fares are discussed below.

MBTA Finance

In fulfilling its mandate to provide mass transportation service, the MBTA incurs costs which must be financed through a number of sources. The MBTA's costs are reflected in an annual budget. The budget is, in turn, developed to insure that total costs and the amount of funds available for the MBTA are equal. In achieving this equilibrium, there is an interplay of a number of variables. On the cost side, increasing fixed costs associated with capital investment, inflation and its impacts on the price of fuel, materials and labor, and an objective to provide the maximum amount of service all result in pressures for increased costs. On the funding side, the overall public policy objective of minimizing public finance (taxes) has created pressure to minimize MBTA funding from standard revenue sources.

Budget

Heightened pressure to contain costs has resulted in strict budgetary limitations in recent years. One outcome of these limitations has been a concerted effort to reduce costs through more efficient utilization of resources as well as through service reductions. Some costs, however, such as principle and interest on long-term bonds are "fixed" and cannot be reduced. Also, the price of supplies is generally "fixed" and cannot be reduced. The two principal methods of cost reduction which have been successful are more efficient utilization of resources and service reductions. (Efforts to control costs are addressed in greater detail in the Management Practices Study.)

Funding

On the funding side of the equation, the MBTA receives support at four levels: Federal, state, local communities, and consumers.

The Federal government provides funds for 80% to 85% of the cost of MBTA capital improvements (these Federally reimbursed costs are not reflected in the MBTA's annual operating budget). The Federal government also provides financial assistance for transit operations. In recent years, the Federal government has reduced the amount of funding available for operating assistance to a current value of only 7% of total funding. As a result, financial assistance from the state has become the greatest source of MBTA funds at approximately 39%. Cities and towns within the MBTA district also contribute to the MBTA's financing through a series of assessment formulae. Communities outside the MBTA district fund the net cost of service which they receive. Proposition 2½ has, however, limited the amount of financing available from communities.

Lastly, consumers are a significant source of MBTA income. Consumers are comprised of those who lease property from or pay for advertising, on the MBTA, and the bulk of MBTA consumers--the ridership. It is this final group, the riders, who are most directly effected by the many actions addressed in this report.

Fare Revenue

The revenue provided by the transit rider, who contributes to MBTA funding through the fare box, is of primary importance in this report.

As a contribution to the financing of the MBTA's total operating expenses, fare revenues declined from 55.6% in 1970 to 26.0% in 1980. Additionally, the average fare per passenger as adjusted for inflation had declined from 30.2 cents to 16.7 cents. In the same decade, the actual cost of gasoline, a major component of the cost of transit's competition, the automobile, had nearly quadrupled while transit fares had increased by approximately one-third.

With Federal, state and local funding sources restricted and with further cost reductions liable to produce unacceptable service levels, the MBTA advanced a fare increase as a means of increasing the funds available for transit operations.

The achievement of a fare revenue goal is dependent on a number of variables. Simplistically, the pricing schedule and number of passenger trips will dictate the amount of revenue to be gained. The number of passenger trips, however, is dependent upon a number of variables in addition to the price of transit. These variables impact transit ridership in both the long run and short run. Among the more significant variables are population and employment levels and patterns. The extent and distribution of people and jobs are major determinants of total trips made by people. Declining population in inner city areas has contributed to declining transit ridership in recent decades. The characteristics of the alternative to transit also affect transit ridership. In the long run, increased auto ownership and availability has provided more travelers with the option of driving. Stable gasoline prices and more fuel-efficient automobiles have reduced the cost of driving in recent years, making driving more attractive. Parking supply and pricing conversely affect the option of using the automobile.

All of these variables, which are beyond the control of the transit manager, affect the level of transit ridership and, in turn, transit revenue. The impact of these variables on transit ridership is difficult to measure, particularly in the short run, and have not been addressed in this report.

Two major ridership variables over which the transit operator has some control are service and price. These variables are addressed in this report. Although the objective of this report is to address the impact of the 1981 fare increase, there have been significant changes in transit service during the same period, and it has been necessary to isolate the impacts of these changes to properly account for the impacts of the fare increase.

Transit fares were increased in 1981 in a direct attempt to increase fare revenue as one element of the MBTA's funding schedule to provide sufficient funds to finance the cost of the MBTA's annual budget. This report assesses the impact of the fare increase with respect to MBTA goals of maximizing transit ridership and improving the environment.

1.1.4 Alternatives Examined

The study scope required the identification and analysis of No-Action and Implementation-Action alternatives as well as several alternative actions to the fare increase as implemented.

The No-Action alternative presents the case that would have occurred had a fare increase not been implemented. According to the MBTA, two possible results of inaction were: a reduction of all service levels shortly after August 1, 1981 or the termination of all service for approximately the months of November and December. Failure to implement a fare increase or reduce service would result in an estimated 1982 budget shortfall of $35 million over that of 1981.

The Implemented-Action alternative is composed of a systemwide fare increase and a series of service restorations instituted at the start of the Fall schedule. In April of 1981, the MBTA reduced service in an effort to alleviate financial problems. With the goal of meeting a 1981 budget, the MBTA Board of Directors adopted a revised schedule with service changes aimed at reducing total manpower requirements by 20% (or approximately 300 surface operators). This set of service reductions, concentrating on the high cost and low ridership MBTA-run and MBTA-subsidized transit services, was initiated during the first quarter of 1981.

A variety of actions were proposed for examination and included strategies such as alternative fare structures, alternative fare payment methods, alternative fare collection systems, legislative programs and alternative funding sources. The bulk of the alternative actions presented are directed toward increasing revenue or ridership associated with specific groups of users (i.e., commuters, elderly, etc.). The actions identified are as follows:

- Peak period pricing is simply the policy of maintaining lower transit fares during off-peak hours. The primary goal of this policy is to increase ridership during the hours that excess capacity exists. The greatest drawback of this policy is that a decrease in off-peak fares leads to a decrease in fare revenue. The impact of this policy on ridership has varied widely from city to city, with Boston showing little or no gain in revenue.

- Off-peak fares for the elderly have been in effect on the MBTA since August 1981. Senior citizens are allowed to ride free between 9:30 AM and 4:00 PM. This program had increased elderly ridership by an estimated 27,000 passengers per day at a cost of $5,000 in lost revenue. (This was ended in December of 1982 when an all-day ten cent fare was instituted by legislative action.)

- Peak period surcharge involves charging a premium for peak period trips to compensate for the additional cost of transporting passengers during this period. This policy would take advantage of the low fare elasticities exhibited by commuters.

- Reduced fares for special groups can be justified in several ways. They can be made available to groups that are considered less capable of paying, such as people of low income and the elderly. In 1979, it was estimated that 23.8% of MBTA passengers had household incomes under $8,000. They may be provided to increase the attractiveness of transit to specific groups such as the handicapped. In addition, lower fares are often used to encourage trips that are deemed to be "in the public good" such as school trips. These actions generally stimulate ridership among the targeted group(s) at the cost of decreased fare revenue.

- Reduced fares for transfers is suggested as an equity measure to offset the relatively high price of short transit trips requiring one or more transfers. Transfer fares may range anywhere from free to full fare. Some transit facilities discount all transfers between vehicles while others limit it to specific combinations (e.g., express bus-rail). Such a plan by necessity implies a gain in ridership coupled with a loss in revenue. Additionally, utilization of paper transfers has historically been difficult to control, subject to abuse, and an added administrative burden.

- Lower fares for downtown travel have been adopted by many cities as part of their downtown revitalization plans. Low fares on downtown loops may reflect a low cost due to limited route length, high density of use, or the lower incremental value of intra-downtown trips to the individual user. In some cities, downtown merchants contribute to the financing of the system. The negative impact of such a system is the loss of revenue from those riders already making trips within the Central Business District.

In addition to the above alternatives, several alternative payment systems have been considered. They are as follows:

- Electronic fare collection systems can be used to set fares by time of day or distance between stations. Tickets purchased at vending machines or outside agents are required to enter and exit the system. Problems associated with this system include equipment failure and the difficulty of implementation for on-vehicle payment (LRV and buses).

- The bulk sale of tokens at a discount allows for effective transit marketing and reduced coin handling costs.

To date, this method had not been implemented due to significant problems with the administration of the sales of bulk tokens.

- Self-service fare collection holds each passenger responsible for determining and paying his own fare. Benefits include increased productivity, the opportunity to introduce a diversified fare structure, lower fare collection costs, and improved passenger statistics. Problems surrounding the implementation of this policy include the high capital cost of ticket vending and verification machines, machine malfunction and vandalism, and enforcement.

1.1.5 Ridership Levels and Elasticity Analysis

Service reductions and fare increases have had a negative effect on MBTA ridership levels. The rider's response to these changes, quantified in terms of elasticities, depends on several factors including: the proportional change in the fare or service levels; trip characteristics such as sub-mode used (bus or rapid transit); time of travel or trip purpose; the socioeconomic characteristics of the rider such as age or income; and the cost characteristics of alternative modes.

In order to summarize the general effects of a fare increase, a review of the effect of fare increases in other cities was carried out. This review reaffirms the conclusions of Curtin (1968) that the ridership response to fare increase is somewhat inelastic, i.e. ridership change is proportionally smaller than the fare change.

A comparison of MBTA ridership levels before and after the fare increase indicates that approximately 90,200 fewer trips were made on an average weekday in November 1981 after implementation of the fare increase than in November 1980. This figure represents about 15.0 percent of the MBTA's total average weekday trips.

These trips may be further broken down according to the reason for the decline:

-56,700 fewer trips (9.4%) - directly due to the fare increase of August 1981

-32,000 fewer trips (5.3%) - due to service cuts

- 1,500 fewer trips (0.2%) - due to bus replacement on the Mattapan High Speed Trolley Line

The most significant changes in the types of riders, were the increase in the number of elderly riders mainly due to free off-peak fare; the increase in the number of pass users; and the decrease in the number of riders who pay the full adult cash fare. The smallest impact was on riders who use only rapid transit. The greatest loss was in the number of trips made using both rapid transit and bus for a single trip.

Bus and rapid transit elasticities were calculated from the change in ridership and fare levels before and after the fare increase. After adjustments were made to isolate the effects of the service reduction from the effects of the fare increase, the fare elasticities were compared with past experience in Boston and other cities. While bus elasticities seem to be in agreement, those for rapid transit were significantly higher than anticipated. This implies that other forces such as a decrease in service reliability and the composite effect of the 1980 and 1981 fare increases might have been acting to discourage ridership.

Elasticities can be a valuable tool in projecting the impact of service or fare changes on ridership levels, given that all the other variables affecting ridership remain unchanged when the fare change occurs.

1.1.6 Environmental Impacts

The most significant environmental impacts that would tend to result from a fare increase relate to changes in air quality and energy consumption. As the cost of public transportation increases and travelers turn from transit, they must either take some other mode of transportation for that trip or not make the trip. If passengers switch to either private automobiles or taxis, the total number of vehicle miles traveled (VMT) as well as highway congestion will increase, causing emissions and energy consumption to rise.

The magnitude of air quality impacts was estimated using an analysis method that considered three types of changes:

1. the change in total regional VMT
2. the change in congestion (queue length) on major Boston radial highways
3. the change in traffic volumes at selected intersections designated as CO (carbon monoxide) Hot Spots

The combined ridership loss due to the fare increases of July 1, 1980 and August 1, 1981 was used in this analysis to estimate the number of passengers diverted from transit to private automobiles or taxis.

Additional regional VMT was estimated based on the number of diverted trips, choice of alternative transportation mode, trip lengths, and the number of passengers per vehicle. An increase of 230,000 daily VMT was estimated, which represents a 0.5 percent growth in the regional total.

The air quality impacts associated with the VMT changes were calculated using EPA emission factors from their MOBILE2 program. The estimated rates of increase in regional emissions are as follows:

Non methane HC - 191.3 tons/year
Exhaust CO - 2,929.2 tons/year
Exhaust NO_x - 242.6 tons/year
Lead - 4.7 tons/year

The air quality impacts of additional highway congestion resulting from diverted trips was then estimated. This analysis uses an expressway queuing model, developed by CTPS, that predicts delays based on daily traffic volumes relative to highway capacities at bottleneck points. The additional automobile trips to and from Boston were proportionally allocated to radial highways to produce predicted traffic volumes. The predicted increase in auto emissions was estimated using the EPA's MOBILE2 automobile emissions factors and queue speeds. Congestion conditions were found to lead to a greater increase in CO and HC emissions than would be anticipated based VMT changes alone, since CO and HC pollutant emission levels increase as vehicle speeds decrease.

The State Implementation Plan outlines the steps that the state will take over the next five years to attain Federal air quality standards. The increase in emissions resulting from the fare increase is estimated to be less than one-half of one percent of the reduction needed by the transportation sector to attain the standards. Presently, it is estimated that the state will attain these standards and provide an additional cushion to accommodate growth. Increased vehicle emissions resulting from the fare increase can be accommodated by this cushion; however, it will reduce the total growth potential allowable within the region.

An analysis of the change in CO concentration at intersections designated by the Massachusetts Department of Environmental Quality Engineering (DEQE) as CO Hot Spots was undertaken as part of this study. A CO Hot Spot is an intersection identified as having high concentrations of CO. The CO Hot Spot Analysis technique used was the EPA's Volume 9 method as modified by DEQE. (This technique considers traffic characteristics such as volumes, intersection configurations, signal timing and speeds as well as meteorological conditions such as wind speed, wind direction and dispersion rates.) None of the intersections were found to exceed the 1-hour standard. However, prior to the fare increase, the 8-hour standard was exceeded at two of the identified intersections. It is estimated that as a result of the fare increase, CO concentrations will increase at one of these intersections and that a third intersection will exceed the 8-hour standard.

Energy consumption impacts relating to the diversion of riders from transit to private automobiles occur on two levels. Initially, it is estimated that motor fuel consumption would increase by 4.6 million gallons/year due to additional VMT. Secondly, the anticipated increase in traffic congestion would cause an increase in fuel consumption of 689,000 gallons per year. The total additional fuel consumption of 5.4 million gallons per year represents one quarter of one percent of the annual motor fuel consumption in the state.

The overall energy efficiency of the MBTA itself, has been found to be increasing over the past few years. Energy efficiency measured in miles/gallon-equivalent has increased by approximately 20% while total consumption has been reduced by roughly 23%.

1.1.7 Socioeconomic Impacts

A basic goal of a public transportation agency is to promote social and economic equity by providing mobility and equality of access to employment, health care, educational, cultural and shopping opportunities. The degree to which it meets this goal is largely determined by its fare and service levels. This section summarizes the impact of recent fare increases on the MBTA's ability to meet the needs of various groups of users.

As expected, the recent fare increases affected low-income riders to a greater extent than those with higher incomes. Depending on the mode used, an individual from a low-income household could spend between 3 and 7 percent of his household income on public transportation. This compares with between 1 and 2 percent for a person from an average income household. However, fewer low-income riders were lost, as compared with other groups, since they tend to have fewer alternative means of travel. As a result, they comprised a larger proportion of daily ridership.

A greater proportion of trips by low-income riders occur on buses and trolleys, as opposed to rapid transit. This would seem to explain the low fare elasticities exhibited by bus and trolley ridership relative to that of rapid transit.

Since 1979, trips made by children (5-11 years) and students have dropped by approximately 28 percent. During this period, non-school-related trips have experienced a proportionally greater decrease in ridership than school-related trips. This may be due to the fact that the MBTA presently allows children with badges to pay half fare for school trips. This subsidy of school trips presently costs the MBTA $2.8 million per year. In addition, communities such as Boston subsidize students who ride the MBTA by buying tokens and passes and distributing them to qualified students.

The Urban Mass Transportation Administration (UMTA) requires that transportation authorities receiving UMTA financial assistance make their facililties available to the elderly for no more than half the full fare during off-peak time periods. The MBTA presently provides free access for the elderly and handicapped between 9:30 AM and 4:00 PM, Monday through Friday. This program has been credited with mitigating some of the adverse effects on ridership of the fare increases. Since the institution of free fares, elderly and handicapped ridership has increased by approximately 13,000 riders per average weekday. The cost of this program to the MBTA is approximately $5.0 million more per year than if half-fares were charged at all times, assuming no ridership loss. (In December of 1982, this free fare for the elderly was ended and a ten cent all-day fare was instituted.)

Discretionary trips are generally more sensitive to changes in fare and service levels than are work or school trips. The discretionary rider has more of an opportunity to change the destination or mode of his trip. Fare and service changes between 1979 and 1981 have caused the number of discretionary trips to decline daily by 33,700 trips or approximately one-third. During this period, the number of daily shopping trips decreased by 16,700. Losses in sales for the entire period, as estimated by downtown merchants, totaled approximately $6 million. These sales are assumed to be shifted from the core to suburban shopping centers which are accessed by automobile.

This analysis has also developed a series of elasticities which were disaggregated by mode, time of day, user income level and trip purpose (specific to the MBTA). These could be used in the future to project the relative impacts of fare policy changes on various socioeconomic groups. In this manner, the MBTA might more closely gauge the revenue and ridership impacts of new fare policies.

1.2 MITIGATING MEASURES

The MBTA has implemented and is investigating measures which would lessen the adverse impacts of the fare increases and service reductions on the environment by encouraging mass transit usage. These measures support the MBTA policy of increasing riders while working to balance the overall financial burden among riders and public revenue sources.

Many of the mitigating measures suggested have a secondary impact on services and operations which, in turn, effect the ability of the MBTA to control costs and increase ridership.

A summary of mitigating measures identified in the conduct of this study and in the Management Practices Report is presented in Table 1-1. The summary presents a reference to the report text, a brief description of the measure and its status.

Type of Measure	Where Described In Report	Description of Measure	Status of Measure
Service			
1. Service Restoration	E.I.R p.52 153-155	The staged restoration of selected services during the summer and fall of 1981, as well as additional restoration during 1982.	Service has been restored on 23 routes and headway and trip time improvements have been made on most routes as of the spring of 1983.
2. Surface Traffic Improvements	E.I.R. p.156	The investigation of measures to improve the flow of surface vehicles, through bus lanes and signal preemption.	Various efforts to improve the flow of buses and surface rail vehicles are under consideration.
3. Service Quality Improvements	E.I.R. p.157	Service Quality Improvements Service quality improvements are being addressed through a multiplicity of ongoing programs. A. Equipment Replacement and Restoration	
		1. Replacement of an average of approximately 100 buses each year to maintain an average fleet age of six years.	Bids are being sought for 20 articulated buses and consideration is being given to additional purchases.
		2. Acquisition of new cars for the Orange (120 cars) and Blue (70) lines is near completion. In addition, the purchase of between 50 and 60 Red Line cars is anticipated as needed, due to the extension of the Red Line to Alewife and increased ridership on the South Shore Line.	Acquisition of 120 Orange Line and 70 Blue Line cars is completed. The bid process for 58 Red Line cars is to start in the fall of 1983 with delivery scheduled for 1986.

SUMMARY TABLE OF MITIGATING MEASURES

TABLE 1-1

(CONT.)

1 OF 7

Type of Measure	Where Described In Report	Description of Measure	Status of Measure
3. Service Quality Improvements (cont.)	E.I.R. p.157-159	Included in this program are:	
		1. The installation of communication cable.	Will proceed concurrently with signal installation.
		2. The installation of an emergency telephone system.	Will proceed concurrently with signal installation.
		3. Computer-aided bus radio system.	Design funds sought for 1983. Installation expected in 1985.
		4. Completion of an MBTA/police radio system in the Authority's tunnels.	Currently begun, completion in 1984.
		D. Track and Structural Improvements	
		A multi-year track renovation program in which all deteriorated and substandard track on the Green Line and the three rapid transit lines will be renewed or replaced. Major track improvements are proposed on the following lines:	
		1. The Blue Line (Airport to Wonderland).	Project to be completed in 1983.
		2. Green Line rights-of-way and track bed rehabilitation.	Green Line (B) to be completed in 1983. Haymarket Portal to Park in 1984.
		E. Station Renovation Projects	
		A number of station modification and renovation projects have been proposed and are in various stages of planning and implementation. Among the projects currently being proposed are:	

SUMMARY TABLE OF MITIGATING MEASURES

TABLE 1-1

(CONT.)
2 OF 7

Type of Measure	Where Described In Report	Description of Measure	Status of Measure
3. Service Quality Improvements (cont.)	E.I.R. p.158, 159	1. Columbia Station.--Enlargement and renovation.	Construction scheduled for 1984-1985.
		2. Kendall Square.--Modernization, enlargement, and improvements to the station and platform.	Construction scheduled for 1984-1985.
		3. Platform lengthening to accommodate six-car trains at Washington, Park Street (Red Line portion), South Station, Central Square, Broadway, and on the Blue Line at the Suffolk Downs station.	Suffolk Downs construction in 1983. Central, Park, and Washington construction in 1984. Broadway and South Station in 1985.
		F. The Maintenance Program	
		A program to provide preventative maintenance and thus reduce operating costs, increase revenue, and productivity, and also improve safety and service quality. This program includes the provision of test equipment, shop tools, machinery, etc., as well as a sufficient quantity of spare replacement parts to maintain a high level of vehicle availability and regularly-scheduled inspections.	
		Collectively, the purpose of improvements such as these is to reduce the number of incidents of system failure and, thereby, improve reliability of the system.	

SUMMARY TABLE OF MITIGATING MEASURES

TABLE 1-1
(CONT.)
3 OF 7

Type of Measure	Where Described In Report	Description of Measure	Status of Measure
3. Service Quality Improvements (cont.)	E.I.R. p.157-159	3. Green Line LRV's are being slated for reconstruction, and general vehicle modifications are being made to insure the durability of the vehicles.	Ongoing project.
		4. Replacement and improvement of carhouses/garages/shops; a major upgrading of the existing facilities used to house and maintain the vehicle fleet.	Replacement facility for Reservoir Carhouse is under construction. Renovation of Quincy and Lynn Bus garages is scheduled to begin in 1983.
		B. Electrical Power Improvements	
		A major classification of renovation projects required to modernize and upgrade the present capabilities of the system. Parts of this project include:	
		1. Conversion from the obsolete 25Hz power system to a centrally-connected 50Hz system.	Completion by the end of 1984.
		2. Resectionalization of the AC/DC feeder cables between substations and tracks.	Design of this program is scheduled for implementation in 1983-1984.
		3. Power cable replacement of deteriorated cable ducts.	Currently is 20 percent. The remainder of the program is scheduled for completion in 1987-1988.
		C. Signals and Communication Improvements	
		A major program for the renewal or replacement of deteriorated or substandard signal equipment on the Red, Blue, and Green lines.	Red Line: Completion in 1984. Blue Line: Beginning in 1984. Green Line: Beginning in 1987.

SUMMARY TABLE OF MITIGATING MEASURES

TABLE 1-1

(CONT.)

4 OF 7

Type of Measure	Where Described In Report	Description of Measure	Status of Measure
Planning			
1. Service Planning Staff Increases	M.P.S.* Touche-Ross p. 21, 22	Increase Service Planning group--three transit planners and five traffic checkers.	Currently in process.
2. Make Service Planning A Priority of All Managers	M.P.S. Appendix B Touche-Ross	Establish a Service Planning Committee of many managers to review service requests.	Was reactivated in May 1982.
3. Revision of 1977 Service Standards	M.P.S. Touche-Ross p. 21, 23	Update these standards to reflect current policy influences on the provision of services. The planning process itself should be reviewed in light of the revised service standards and should include the procedure and deadlines for new service requests.	Final report is scheduled for completion at the end of 1983.
4. Automation of Simple Service Planning Functions	M.P.S. Touche-Ross p. 24	Micro-computer acquisition and use by the service planning office to facilitate data management. Scheduling operations continue the transition from manual systems to automated systems.	A TRS-80 microcomputer was installed in 1983. Service Planning Staff is currently participating in an APTA-UMTA Productivity Program.
5. Improvement of the Planning Data Base	M.P.S. Touche-Ross p. 24	Internal and external data on traffic counts, passenger counts of other authorities, and school enrollments should be maintained for use by the Service Planning Staff.	The Central Transportation Planning Staff is establishing a staff support group for assistance in maintaining a comprehensive data base.
Efficiency			
1. Preventative Maintenance	M.P.S. Appendix A Touche-Ross p. 57	Preventative maintenance emphasis increased. Establishment of vehicle maintenance standards should be developed and closely adhered to.	A formal program of vehicle inspection has been established. A system of programmed maintenance and parts acquisition is scheduled to be in operation by the end of 1983.

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*Management Practices Study.

SUMMARY TABLE OF MITIGATING MEASURES

TABLE 1-1

(CONT.)

5 OF 7

Type of Measure	Where Described In Report	Description of Measure	Status of Measure
1. Preventative Maintenance (cont.)	M.P.S. Appendix A Touche-Ross p. 57	Quality control function for preventative maintenance.	The system is scheduled to be in operation by the end of 1983.
2. Fuel Consumption Review	M.P.S Appendix A Touche-Ross p. 58	An energy review and monitoring of MBTA rapid rail fuel consumption.	A new monitoring system will be complete by 1984.
Management			
1. Management Rights	E.I.R. p.161 Appendix D	Effect more efficient, productive operations through the passage of management rights provisions of Chapter 581 of the Acts of 1980.	Measure was passed in 1981 and additional actions continue to be added.
2. Increased Emphasis on Management Information Systems	M.P.S. p. 3	Upgrading of the Management of Information Systems to the status of a Directorate.	In 1982 this occurred.
3. Ridership Information Collection	E.I.R. p.162 Appendix A-5	Improved data collection procedures:	
		1. Evaluation of the SENTRY project for use.	Completion in late 1983.
		2. Continue with the annual (November) sampling program.	Occurred in 1982 and is planned for continuation on an annual basis.
4. Performance Evaluation System	M.P.S. Appendix A Appendix A p. 56	Development and systematic use of performance standards for evaluating the quality of service provision.	Has been instituted and is being refined.
5. Management Practices Study	E.I.R. p.162	A study of management practices that "outlines more efficient management procedures."	This was completed on October 29, 1982.

SUMMARY TABLE OF MITIGATING MEASURES

TABLE 1-1
(CONT.)
6 OF 7

Type of Measure	Where Described In Report	Description of Measure	Status of Measure
6. Operator Work Rules	M.P.S. Appendix B Touche-Ross p. 25	Operator work rule changes should be implemented, including:	
		1. Reducing the number of operator picks to three annually.	Are being addressed by the Transportation Management Improvement Plan Task Force.
		2. Assigning "extra" work trips on a volunteer basis.	
		3. Greater flexibility in assigning cover personnel.	
7. Productivity Measurement	E.I.R. p.379	Improved Productivity Measurement Programs and their coordination to insure an ability to monitor progress.	
8. Manager Evaluation Process	M.P.S. Appendix C Touche-Ross P. 17	Improve manager evaluation process to be more goal oriented and performance based:	All four operations departments will have their performance indicators finalyzed by mid-1983.
		1. Give the personnel department monitoring responsibility.	This has been done.
		2. Establish a probation policy.	
		3. Establish a Bonus/Incentive Program.	
		4. Train the managers to establish objectives and evaluate employees against those objectives.	Top executives have attended training session in implementing the evaluation process.
9. Maintenance Staff	M.P.S. Appendix A Touche-Ross P. 57	Maintenance staffing mix should be adjusted. More different levels of mechanics and repair staff should be established, and lower level functions should be contracted to outside contractors.	30 new third class mechanics have been hired and 9 more are to be hired by the fall of 1983. First and second class mechanics have been reassigned to do maintenance and repair work.

Summary Table of Mitigating Measures

Table 1-1

(Cont.)
7 of 7

1.3 FINDINGS AND RECOMMENDATIONS

Transit fares were increased in 1981 to increase the fare-revenue element of the MBTA's funding schedule for providing sufficient funds to cover the cost of the MBTA's annual budget. This report assesses the impact of the fare increase with respect to goals of maximizing transit ridership and improving the environment.

1.3.1 FINDINGS

In the course of preparing the Environmental and Socioeconomic Impact Report, a number of findings have been made. These findings include both impacts of the fare increase and opportunities identified in various areas of MBTA operations, service provision, or management to provide mitigating measures to such impacts.

1.3.1.1 Impacts

The primary objective of the MBTA fare increase was to raise sufficient funds through user charges to retain adequate service levels and to be in compliance with the expressed goal of reducing public sector reliance on local taxes. The objective was to accomplish this with a minimum of adverse impact on environmental quality, energy consumption, and social equity. The primary indicators that were chosen as a measure of whether the objectives of the fare increase were being realized were actual levels of revenue and ridership compared with predicted levels.

Measurements and analysis of the impacts of the 1981 fare increase have occurred concurrently with both the fare increase and the subsequent decrease in fare levels. This timing has allowed for some of the new ridership (post-increase) estimates to be derived as the result of a direct fare mix sampling study conducted in November, 1981.

It should be noted that this approach is somewhat unusual in that ordinarily an Environmental Impact Report (EIR) would contain predictive information on ridership and environmental quality in advance of the implementation of the program. Thus, no actual data on ridership change usually accompanies the EIR.

Environmental data provided is solely from modeling efforts and does not include any sampling or data collection performed after the fare increase was instituted.

Impacts of the 1981 fare increase are described in detail in the body of the report. Some of the more notable impacts have been grouped into four categories--revenue, ridership, environment and energy--and are described below.

A. Revenue

Before the fare increase was instituted, a package of fare and zonal changes had been proposed and was calculated to have a potential of increasing revenue by $24.4 million. This fare change package was never implemented and was altered to mitigate the impacts on special groups which would have been adversely affected by uniform fare change. The package differed from the implemented fare increase in that it had a different timing for pass price increases, different rapid rail fare zones, fares for the elderly and other changes from the implemented fare increase. As instituted, the 1981 fare increase was anticipated to produce $17 million in increased revenue in 1981.

- The 1981 revenue generated from the fare increase, as adjusted for service-related impacts, has been estimated at approximately $13.6 million.
- The 1981 revenue generated from the fare increase, as adjusted for service-related impacts, has been estimated at $13.6 million ($9.5 million net increase in revenue plus $4.1 million in service-related revenue losses).
- The principal reason for the difference between the actual and projected revenue increases was limitations in the MBTA's revenue/ridership data base and associated errors in estimation.
- Revenue lost to the MBTA as a result of reduced fare programs for children, students, elderly and the handicapped is an estimated $15.2 million per year, or 19% of annual fare revenue.

B. Ridership

- A comparison of November, 1980 to November, 1981 ridership levels indicates that approximately 90,000 fewer trips were made on an average weekday. This translates into a loss of roughly 15.0 percent of the average weekday trips made on the MBTA. Of the 90,000 trips, it is estimated that approximately 57,000 fewer trips (9.4 percent) were made because of the fare increase of August, 1981. Service cuts accounted for an estimated loss of 32,000 trips (5.3 percent) on an average weekday.
- There was an estimated increase of 35.8 percent (16,600) in daily transit trips by the elderly.

- Also, there was a ridership decline in the student and children category of an estimated 24.4 percent, a 14,500 decrease in the number of daily trips by this group.

- The method of fare payment that riders chose shifted as pass discounts became more attractive. This was demonstrated by a 15 percent increase in the use of prepaid passes.

- With the exception of the elderly and handicapped fare groups, the fare increase has tended to have a greater economic effect on those who are transit dependent and especially persons of low income. Riders from low-income households were estimated to be spending an average of 4.2 percent of household income on transit fares before the 1981 fare increase, and 6.5 percent after the increase. This compares with 1.5 and 2.3 percent, respectively, for average income households. The fare increase thus had a greater impact (2.3% of house-hold income) on the low-income user than the average-income user (0.8%). In addition, fewer trips were lost from the low-income group of users as compared to other groups, as they tend to have fewer alternative travel choices.

- For each user category in which the fare was increased, the change resulted in a net increase in fare revenue. That is, after adjusting for ridership loss or increase, the fare increase always resulted in an increase in revenue to the MBTA. Fare reductions for each user category always resulted in a net revenue loss.

C. Environmental Quality

As the cost of public transportation increases and travelers use transit less, a portion of the trips previously made by transit will be made by another transportation mode. If passengers switch to either private automobiles or taxi services, the total number of vehicle miles traveled (VMT) will increase.

As a result of this increase in vehicle miles traveled, pollutant emission levels and energy consumption levels will rise. In addition, added traffic congestion will produce a further increase in both emissions and energy consumption.

- Based on the estimated increases in VMT and congestion resulting from the 1980 and 1981 fare increase, non-methane hydrocarbon emissions, which may be used as a general air quality indicator, are estimated to have increased by 191.3 tons/year (476 kg/day) in the region. Of this amount, approximately 105 to 125 tons per year can be attributed to the 1981 fare increase. Other emissions, including oxides of nitrogen and lead, are also expected to have risen on the regional level.

- Carbon monoxide (CO) is a localized emission problem for which 1-hour and 8-hour standards exist. The fare increase is estimated to cause exceedance of the 8-hour standard at one intersection and further exceedance of the standard at a second intersection.
- To achieve the air quality standard for non-methane organic compounds (NMOC) by 1987 requires a reduction of 35% in NMOC emissions. Programmed activities including Federal motor vehicle emission controls, state motor vehicle inspection and maintenance programs, and control of point source emissions will reduce NMOC emissions by 41%, 6% below the standard. Increased emissions associated with the fare increase will increase NMOC emissions by 0.189%.
- The 1982 Transportation Element of the State Implementation Plan for the Boston Region provides an analysis of the reasonably available control measures (RACM's) and programs adopted for implementation since 1979. The sum of these emission reductions which are needed for the Boston region to achieve its yearly air quality attainment goal for 1982 are estimated to be directly off set by the emissions associated with the 1981 fare increase. In order to attain these goals, it would become necessary to implement all of the adopted RACMs. This would leave no additional margin for any unexpected increases in emissions. Furthermore, the region's commitment to achievement of "reasonable further progress" towards the mandated 1987 attainment goals will be adversely affected.

D. Energy

- A 10 percent decrease in ridership, without changes in service levels, has no significant impact on levels of energy consumed by the MBTA.
- Overall, the MBTA has succeeded in improving its energy efficiency during the period of ridership loss.
- Between 1980 and 1981, the diversion of riders from public transportation to automobiles increased motor fuel consumption by an estimated 4.7 million gallons per year. Of this amount, approximately 1.9 million gallons can be attributed to the 1981 fare increase.

- In addition, 689,000 gallons per year is estimated to be required in fuel consumption which would occur due to roadway congestion resulting from the fare increase.
- Total additional consumption of approximately 5.4 million gallons per year represents one quarter of one percent of the annual motor fuel consumption in the state.

1.3.1.2 Problem Identification

A. Institutional

- The Regulations of the Executive Office of Environmental Affairs (EOEA), as adopted in accordance with the Massachusetts Environmental Protection Act, require that an Environmental Notification Form be filed with EOEA prior to implementation of a fare increase of more than 30 percent. The filing of said "Notice" is the initial step in an eleven-step environmental process. This process can be very time consuming, thereby precluding MBTA management from adjusting transit pricing in a timely manner. (In this instance, the environmental process has taken over one year. The actual fare increase was expedited by the granting by EOEA of permission to prepare a "Generic" Environmental Impact Report after the fare increase was implemented.) Compliance with the Regulations, by virtue of the time requirements, limits MBTA management in instituting a fare increase.
- Also, the MBTA's enabling act (Chapter 161A of the Massachusetts General Laws) provides that local transit fares cannot be altered without prior approval of the MBTA's Advisory Board. This places an additional time constraint on adjusting fares.

B. Data and Revenue Collection

As stated previously, the EOEA agreed to waive the conventional environmental impact review process. The Authority agreed to prepare a "Generic Environmental Impact Report" after the fare increase was implemented so as to measure the actual impacts of the fare increase. Specifically, ridership levels were agreed to be a useful indicator of significant impacts of the fare increase. There were, however, major difficulties found in attempting to determine the ridership impacts, as there were difficulties in establishing an adequate ridership/fare baseline for previous years.

To help gather current data, the MBTA, with the assistance of the Central Transportation Planning Staff

(CTPS), designed and implemented a Ridership and Fare Mix Sampling Program with the primary purpose of estimating ridership by fare category. This program was conducted during November, 1981, to comply with the EOEA/MBTA agreement which required that November, 1981 ridership be compared with November, 1980 ridership. The results of this survey appear to provide a reasonable estimation for the average weekday ridership during November, 1981. Unfortunately, no similar data base was available for November, 1980. As a result, the Authority was concerned with comparability of data. Creation of a comparable data base for 1980 was based on solid data where it was available and beyond that is based on a series of assumptions. Although these assumptions appeared reasonable when viewed independently, they do introduce a degree of uncertainty into the calculations.

Furthermore, the collection of usable and comparable revenue data for rapid transit and surface routes has been marked by a variety of data collection and reliability problems. Problems associated with monitoring the access at rapid transit stations hindered the data collection activities and included malfunctioning turnstiles and passreaders and the authorized and unauthorized use of gates. Because of the malfunctioning equipment, not all passengers using turnstiles were properly recorded by the meters. Authorized use of gates presented the necessity to perform special passenger counts while unauthorized use of gates permitted passengers to enter the platform areas unrecorded. In some instances, corrective factors were applied to the survey data to compensate for this problem. Yet, in all likelihood, this segment of ridership was undercounted. Generally, all revenue data available has tended to be somewhat inaccurate due to such counting factors.

Furthermore, data on ridership characteristics, notably socioeconomic characteristics has not been systematically maintained and, thus, must be derived from passenger profiles which may not reflect the current situation.

The confidence level for the 1981 ridership estimate is relatively high, especially for the measurements which resulted directly from the November, 1981 Ridership and Fare Mix Survey. The method used for estimation of 1980 ridership, however, is marked by uncertainty.

- The absence of a reliable data base prior to 1981 hampered efforts to estimate the impacts of the fare increase on revenue and ridership both before and after the fare increase was implemented.

- Open gates and their use creates potential for fare avoidance and makes ridership estimation and revenue control difficult.

- Malfunctioning turnstiles and passreaders create problems for both ridership estimation and revenue control.

C. Impact Assessment

The assessment of the environmental, energy and socioeconomic impacts principally used the results of the ridership survey for base data. The impacts were derived by assessing how the changes in ridership would create a variety of associated impacts. Interpretation of these results is difficult due to the uncertainty of the base data, and due to the purposes and typical applications of the modeling techniques. Modeling techniques were used particularly for the air quality impacts: no air quality sampling programs were initiated. Models were employed to estimate emission levels of various air pollutants.

An additional problem was the difficulty in estimating the traffic diversions due to the 1981 fare increase. The traffic diversion assumed in the study is that resulting from the combined effect of the 1980 and 1981 fare increases. The impacts of the 1981 fare increase, the subject of the study, are not independently estimated or sampled.

- Low cost techniques currently available for estimating air quality impacts which can be applied in a short time period produce results of limited accuracy.

1.3.2 RECOMMENDATIONS

Recommendations are made in five areas:

- Institutional, which addresses the manner in which future fare increases should be considered.

- Fare structure, which addresses considerations for future fare adjustments.

- Revenue collection, which addresses the manner in which revenue is collected.

- Management and Systems Efficiency, which addresses the efficiency of the system and its management.

- Data collection, which considers the data base necessary to estimate ridership and revenue reliably and to assess their impacts.

1.3.2.1 Institutional

To avoid institutional delays in implementing fare increases and to avoid the potential for acute impacts on the environment, it is recommended that:

- An MBTA Fare Committee be reestablished to develop fare policy recommendations and oversee their implementation.
- A policy be adopted establishing a fare revenue goal as a percentage of the annual expense of operating MBTA services (such as 30%) exclusive of fixed charges and private carrier subsidies.
- Fare revenue goals be reviewed annually and fare schedules adjusted, as appropriate, in conjunction with the MBTA's annual budget development process, commencing with the fiscal year 1985 budget.
- Proposed fare adjustments be developed early in the MBTA budget process so as to permit updating of the Environmental Impact Report (if necessary) prior to implementation of the action.
- The Environmental Impact Report (EIS) be updated in the event of a fare increase or an annual reduction in vehicle miles of scheduled service of greater than 10%.
- The EIR update should address fare and/or service change impacts on transit ridership and, in turn, on energy use, air pollution, and traffic and on measures to mitigate any adverse impacts on the environment.
- The data base and methodologies utilized in preparation of this document are modified to improve accuracy and/or reduce the work effort to be applied in updating the EIR.
- Data bases for making decisions and preparing impact analyses be maintained.

1.3.2.2 Fare Structure

In the event of future fare adjustments, it is recommended that the following be considered:

- The basic zone fare system adopted in 1981 be retained.
- Since fare reductions will result in reductions in total revenues, fare decreases be avoided.
- Proposed fare reductions be accompanied by the identification of alternative funding.

- Future fare adjustments minimize the impact of increases upon riders by minimizing increases for short trips, especially those requiring transfers.

- The fare program for handicapped persons be reviewed to assess the potential for simplifying the fare schedule through establishing a common fare for both elderly and handicapped persons and to assess the effectiveness of program eligibility requirements.

1.3.2.3 Revenue Collection

- To minimize potential for fare evasion, it is recommended that control of station entry and exit be tightened by securing all gates which are not under the direct control of MBTA personnel and by assuring that all gate locks which are remotely controlled by collectors are secure and in good operating condition.

- To permit more flexible fare schedules in the long-term, it is recommended that the Pass Program be advanced as follows:

  - The actions necessary to sustain a high percentage of operable pass reader equipment be advanced.

  - Upon achieving reliable pass reader equipment operation, that the expansion of the pass reader program be advanced.

  - The potential for selling passes from collector's booths at the busier transit stations at the end of each month be explored.

- To reduce lines of token purchasers, it is recommended that:

  - The potential for reassignment of gatemen as collectors at stations, for time periods in which lines are longest, be explored.

  - The option of selling tokens in bulk at a reduced price be further pursued.

1.3.2.4 Data Collection and Service Planning

To provide reliable estimates of ridership as required to track system performance and project ridership and revenue, it is recommended that:

- The Ridership and Fare Mix Survey conducted in November 1981 be repeated on an annual basis. The objectives to be met are:

  1. To estimate ridership based on currently collected revenue data.

2. To incorporate Section 15 reporting requirements to the extent that it is practical to do so.

3. To enhance the survey technique and to evaluate it along with alternative programs for estimating ridership.

4. Where practical, to construct a ridership data base which improves the socioeconomic data currently available for conducting impact analysis.

- Fare collection equipment be monitored and maintained to assure reliable operation and accurate readings.
- Revenue and ridership reports generated from fare collection equipment readings be produced in a timely manner.
- The SENTRY project be evaluated for standard use in data collection and monitoring.
- Simple service planning functions be automated to enhance the capability of the MBTA Service Planning Office for additional functions.

2.0 EXISTING CONDITIONS

2.1 ADMINISTRATIVE STRUCTURE

The MBTA was formed under Chapter 563 of the Acts of 1964, which abolished the Metropolitan Transit Authority and assigned its functions and equipment to the MBTA. The MBTA district includes the original 14 cities and towns in the MTA district and was expanded to include 79 cities and towns in the Boston metropolitan area. This area is shown in Figure 2-1.

Since 1964, two reorganization bills have been approved that change the administrative structure of the MBTA.* The MBTA is currently controlled by a seven member Board of Directors; the Secretary of Transportation is Chairman of the Board. A General Manager controls the day-to-day operations of the MBTA. The MBTA Advisory Board, composed of local officials representing the towns in the district, reviews and approves the annual operating budget.

2.2 DESCRIPTION OF THE EXISTING SYSTEM

The MBTA currently provides rapid transit, light rail, trackless trolley, bus, and commuter rail services throughout the Boston metropolitan area. The distinctions between different types of transit are described in Table 2-1.

2.2.1 Commuter Rail Transit

The commuter rail network is composed of the Northern and Southern Divisions, each of which consists of four routes. The rolling stock for the northern routes was acquired from the Boston and Maine Corporation in late 1976; the rolling stock for the southern routes was acquired from Consolidated Rail Corporation, also in 1976. The B&M currently operates both divisions for the MBTA. Fares on the commuter rail system are zoned and range from $1.25 to $4.50. Transfer from the commuter rail to the rapid rail system is possible at both North and South Stations. As shown in Figure 2-2, parking is provided at most commuter rail stations.

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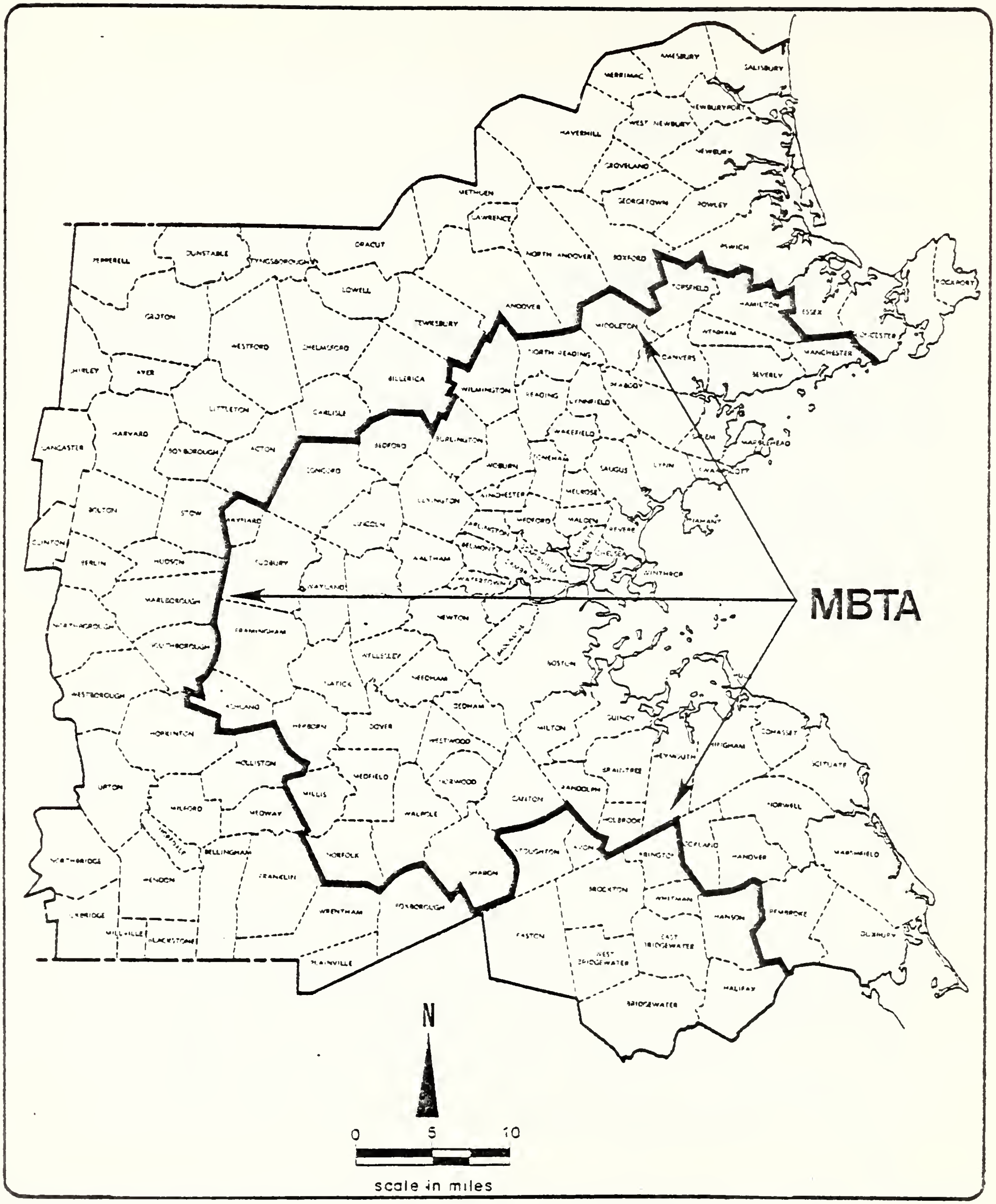
*Appendix A-5 includes a brief description of these changes.



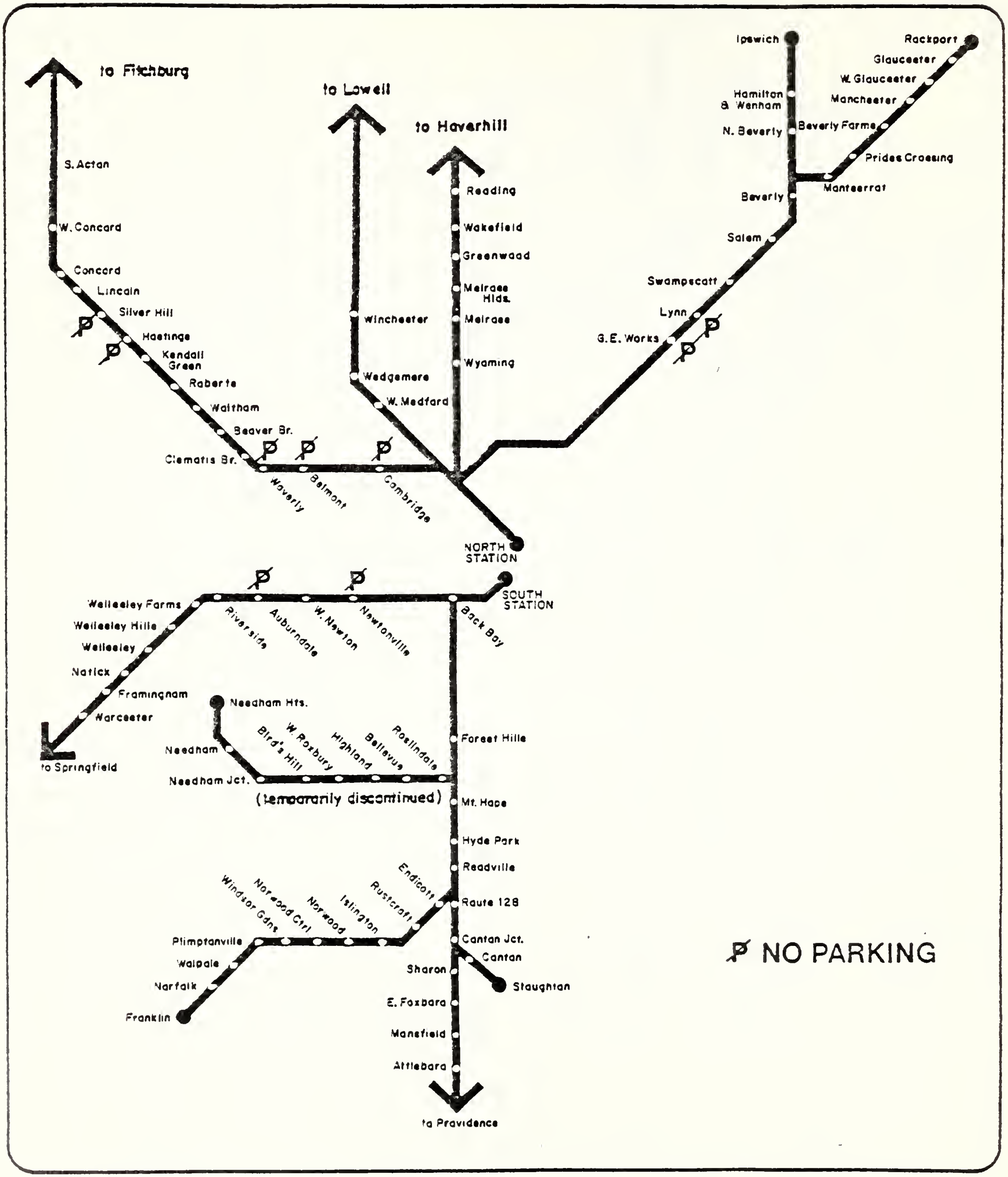
THE MBTA DISTRICT

FIGURE 2-1

	Commuter Rail	Rapid Rail Transit	Light Rail Transit	Trackless Trolley	Bus
right-of-way	exclusive	exclusive	exclusive, street median, and mixed	non-exclusive	non-exclusive
grade crossings	few	none	many	n/applicable	n/applicable
grade	frequently at-grade	grade-separated	grade-separated and occasionally at grade	on-street	on-street
entry	mixed	high platform	low or no platform	on street	on street
stops (spacing)	more than one mile	1/4 - 1 1/2 miles	1/4 mile - 1/5 mile	1/8 - 1/10 mile	1/8 - 1/10 mile (local)
speed	30 mph+	15-25 mph	8-15 mph	10-15 mph	10-15 mph
consists of	commonly multi-car 4 cars+	usually multi-car 2-5 cars	one to 3 cars	bus-sized adapted vehicle	common bus
fare collection type	pre-paid	pre-paid	pre-paid and on-board collection	on-board collection	on-board collection
vehicles	range of typical rail cars	range of typical subway cars	PCC and LRV	usually bus-type trolleys	range of buses
power	diesel	electric, 3rd rail	electric, overhead lines	electric, overhead lines	diesel engines
stop configuration	on-line	on-line	on-line	on-line	off-line

TABLE 2-1

DESCRIPTION OF TYPES OF TRANSIT PROVIDED BY THE MBTA



COMMUTER RAIL NETWORK

Figure 2-2

2.2.2 Rapid Rail Transit

A map of rail transit services is shown in Figure 2-3. Major transfer points between modes are displayed in this figure as well.

The MBTA operates 344 rapid rail vehicles over three separate lines. The Red Line extends from Harvard Square in Cambridge through downtown Boston to Columbia Station in South Boston. At that point, it divides into two branches; one that continues through Quincy to Braintree and one that terminates in Dorchester. The Orange Line extends from Forest Hills Station in Jamaica Plain through Roxbury and the South End, to downtown Boston. It then continues northward through Charlestown and Medford into Malden. The MBTA's Blue Line originates at Wonderland Station in Revere and travels through East Boston into downtown Boston. Free transfers between lines are provided at six downtown Boston stations. These are shown in Figure 2-3.

Two major projects are currently being undertaken to improve the rapid rail system. The Southwest Corridor Project involves the relocation of the Orange Line south of Essex Station to a railroad right-of-way west of the existing elevated line. This segment will be approximately 4.7 miles long with eight new stations. The line will share the right-of-way with long-distance commuter rail services, which will also use three of the eight stations.

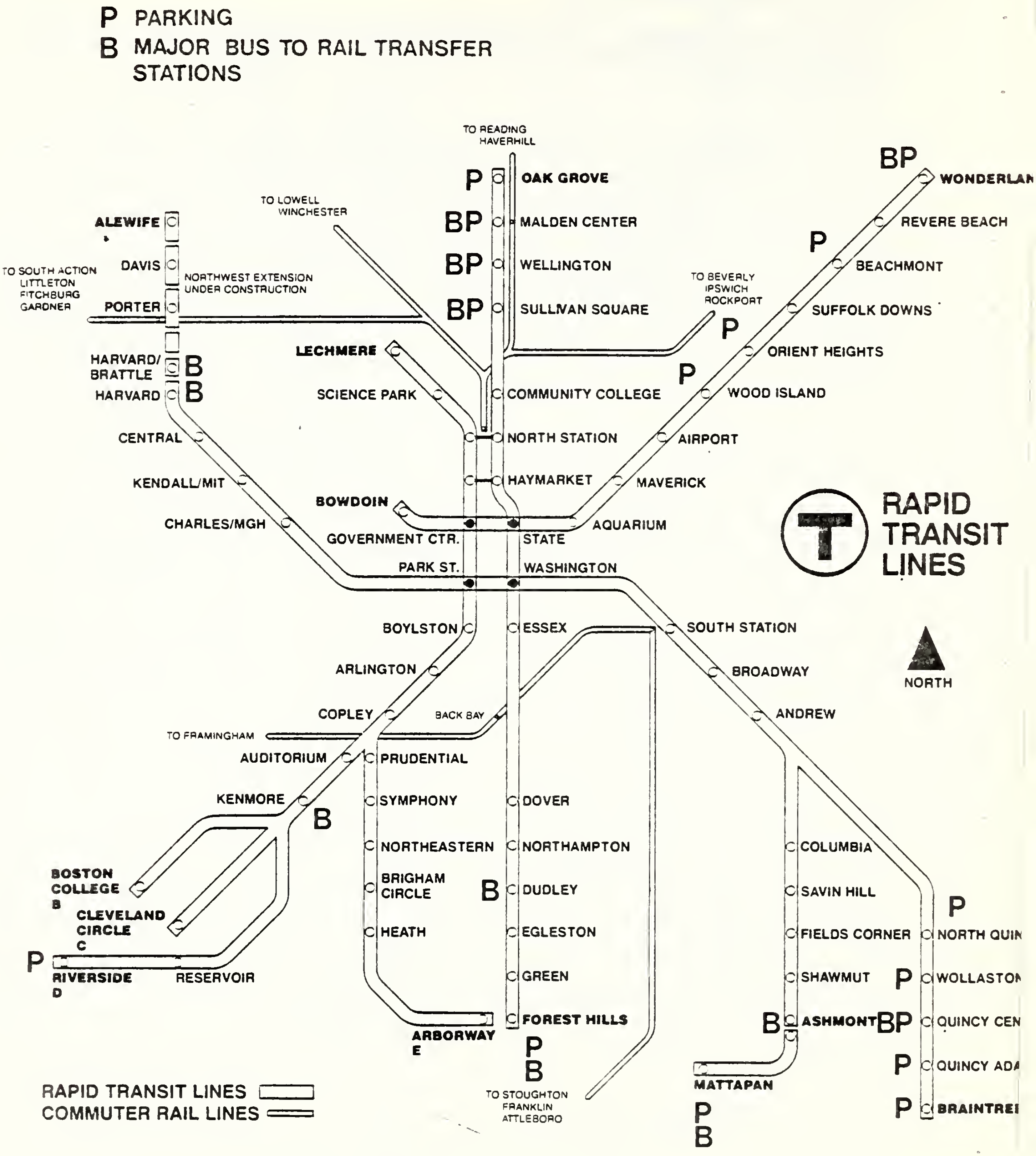
The Northwest Extension Project involves the construction of a 3.2 mile extension of the Red Line between Harvard Square and Alewife. This segment will contain three new stations, with a 2,000 space parking garage at the terminus.

2.2.3 Light Rail Service

The MBTA provides light rail service on the Green Line and Mattapan High Speed Line. The Green Line runs from Lechmere Station in East Cambridge through downtown Boston where it branches into four lines. The Arborway line runs from Copley Square to Jamaica Plain; the other three lines carry passengers between Kenmore Square and either Riverside or Boston College in Newton, and Cleveland Circle in Brighton. Service on the Mattapan trolley line, which runs between Mattapan Square and Ashmont Station in Dorchester, was restored in January 1981 following track improvements. The MBTA operates 339 light rail vehicles of which 209 are the older PCC variety and 130 are the new LRVs.

2.2.4 Trackless Trolley

There are 50 trackless trolleys used principally in the city of Cambridge and in the Watertown/Belmont area for weekday service. These vehicles travel at street grade and follow electrified



M.B.T.A. Rapid Transit Network (1982)

Figure 2-3

overhead lines. They operate much the same as buses, although they are slightly less flexible in routing due to their defined energy requirements.

2.2.5 Bus Transit System

The bus system operates out of nine garages spread throughout the MBTA region (Figure 2-4). Bus routes are expected to fill one or more of the following service functions:

- Linehaul - Direct travel over distances greater than two miles between a residential area and an activity center.
- Feeder/Distributor - Access to and from a service providing linehaul bus, rapid transit, streetcar, or commuter rail service.
- Crosstown - Connects either community subcenters or radial linehaul services.
- Inter-City - Travel between cities or towns, primarily in suburban areas.

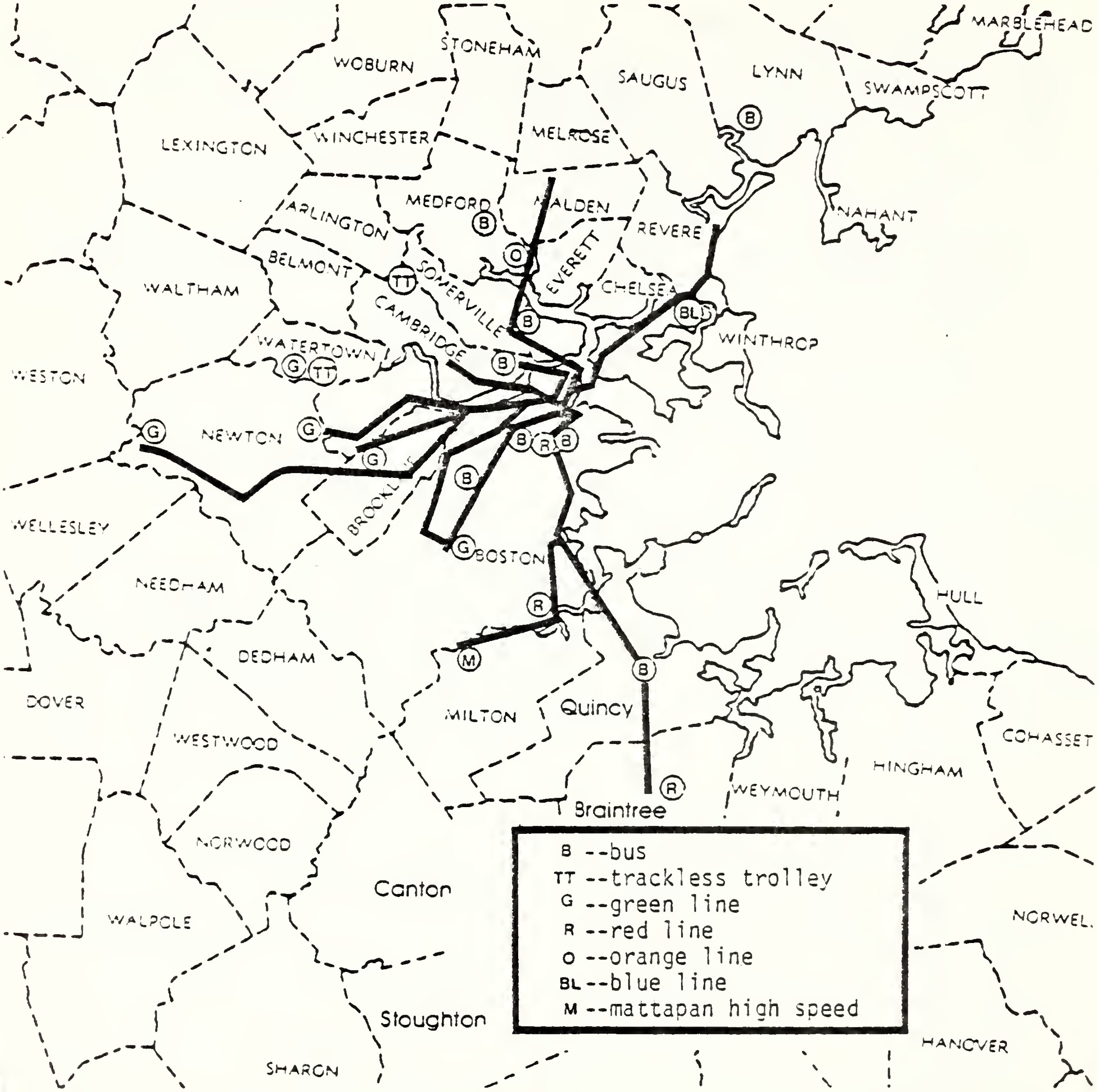
Major bus-to-rail connections are noted in Figure 2-3.

Bus fares are zoned with a 50 cent base fare on local buses for six miles and an additional 25 cents for each additional three-mile zone traversed. The MBTA owns 1,213 buses, of which 1,023 are actively used in operations. The number of vehicles, average vehicle age, and number of routes based at each garage are displayed in Table 2-2 (A and B). These tables also provide this information for rapid-rail, light-rail, and trackless-trolley services.

2.3 RIDERSHIP TRENDS

The MBTA's ridership levels were approximately 511,000 trips per average weekday in November 1981 for the rapid transit, bus, and trolley systems. The commuter rail service accounts for an additional 35,000 trips per average weekday. Historic ridership levels are listed in Table 2-3 and are displayed graphically in Figure 2-5 so that major trends can be observed.

In evaluating this information, it is critical to note that the values presented are estimates which have been produced from a variety of data sources. In the past, the MBTA has not maintained systemwide counts of passengers riding the vehicles. Rather, ridership counts were derived by taking a total of revenue collected and dividing this by an estimate of the average fare paid by each rider. Using this method, it becomes essential to use an accurate average fare value and the calculation of such



MBTA BUS GARAGES AND RAIL VEHICLE YARDS

Figure 2-4

MBTA Vehicle Assignments (as of April 1, 1981)

Mode Type	Garage/Storage Facility	No. of Vehicles	Average Age In Yrs.	No. of Based Routes	Vehicles Required In AM Peak	Average No. Vehicles Available AM Peak[1]	Average No. Vehicles Shortage in AM Peak
Bus	Albany Street[2]	130	3.7	16	112	112	0
Bus	Arborway	182	7.0	23	146	141	5
Bus	Cabot	194	8.6	22	127	112	15
Bus	Charlestown & Bennett	207	7.8	22	183	164	19
Bus	Eagle Street[3]	61	4.9	10	37	37	0
Bus	Fellsway[2]	75	15.3	11	65	65	0
Bus	Lynn	87	9.6	22	67	67	0
Bus	Quincy	87	8.5	16	73	73	0
	SUBTOTAL	1,023	7.9	142	810	771	39
Rail	Green Line	306	18.2	4	110	130	0
Rail	Orange Line	88	11.5	1	64	78	0
Rail	Red Line	164	14.1	2	104	108	0
Rail	Blue Line	92	18.7	1	40	57	0
	Trackless Trolley[4]	50	4.0	3	19	50	0

Source: MBTA, Title VI - Assessment for Capital and Operating Assistance, August 1981, and MBTA Bus and Rapid Transit Service Reports.

[1] Averages are for the first three days of the month. Service and schedule changes were instituted on April 4.

[2] Vehicles are operated out of Albany Street and Fellsway only during weekdays. Evening, weekend, and holiday service is provided for Albany-served routes by the Cabot Garage, and Fellsway-served routes by the Charlestown Garage.

[3] Eagle Street was closed on April 4, 1981, with vehicles reassigned to Charlestown and Lynn.

[4] Vehicles are operated only during weekdays.

Note: Vehicles available reflect the number of vehicles that are available at the beginning of the three hour peak period. They do not reflect vehicles that cannot be used during the entire period because of malfunctions.

MBTA Vehicle Assignments (as of April 1, 1981)

TABLE

2-2 (A)

MBTA Vehicle Assignments for Rating Period Beginning on April 4, 1981
(after spring service adjustments)

Mode Type	Garage/Storage Facility	No. of Vehicles	Vehicles Required In AM Peak	Average No. Vehicles Available AM Peak[1]	Average No. Vehicles Shortage in AM Peak
Bus	Albany Street[2]	130	89	89	0
Bus	Arborway	186	124	124	0
Bus	Cabot	199	98	98	0
Bus	Charlestown & Bennett	227	179	178	1
Bus	Fellsway	87	57	57	0
Bus	Lynn	97	81	80	1
Bus	Quincy	99	70	70	0
	SUBTOTAL	1,025	698	696	2
Rail	Green Line	166	98	127	0
Rail	Orange Line	88	64	78	0
Rail	Red Line	164	104	98	6
Rail	Blue Line	70	40	57	0
	Trackless Trolley[3]	50	19	50	0

Source: MBTA Bus and Rapid Transit Service Reports.

[1] Average number of vehicles available on weekdays during the month of April 1981 (excluding the 1st and 3rd of the month which was part of another rating period).

[2] Vehicles are operated out of Albany Street and Fellsway only during weekdays. Evening, weekend, and holiday service is provided for Albany-served routes by the Cabot Garage, and Fellsway-served routes by the Charlestown Garage.

[3] Vehicles operated only during weekdays.

MBTA Vehicle Assignments for Rating Period Beginning on April 4, 1981
(after spring service adjustments)

TABLE

2-2 (B)

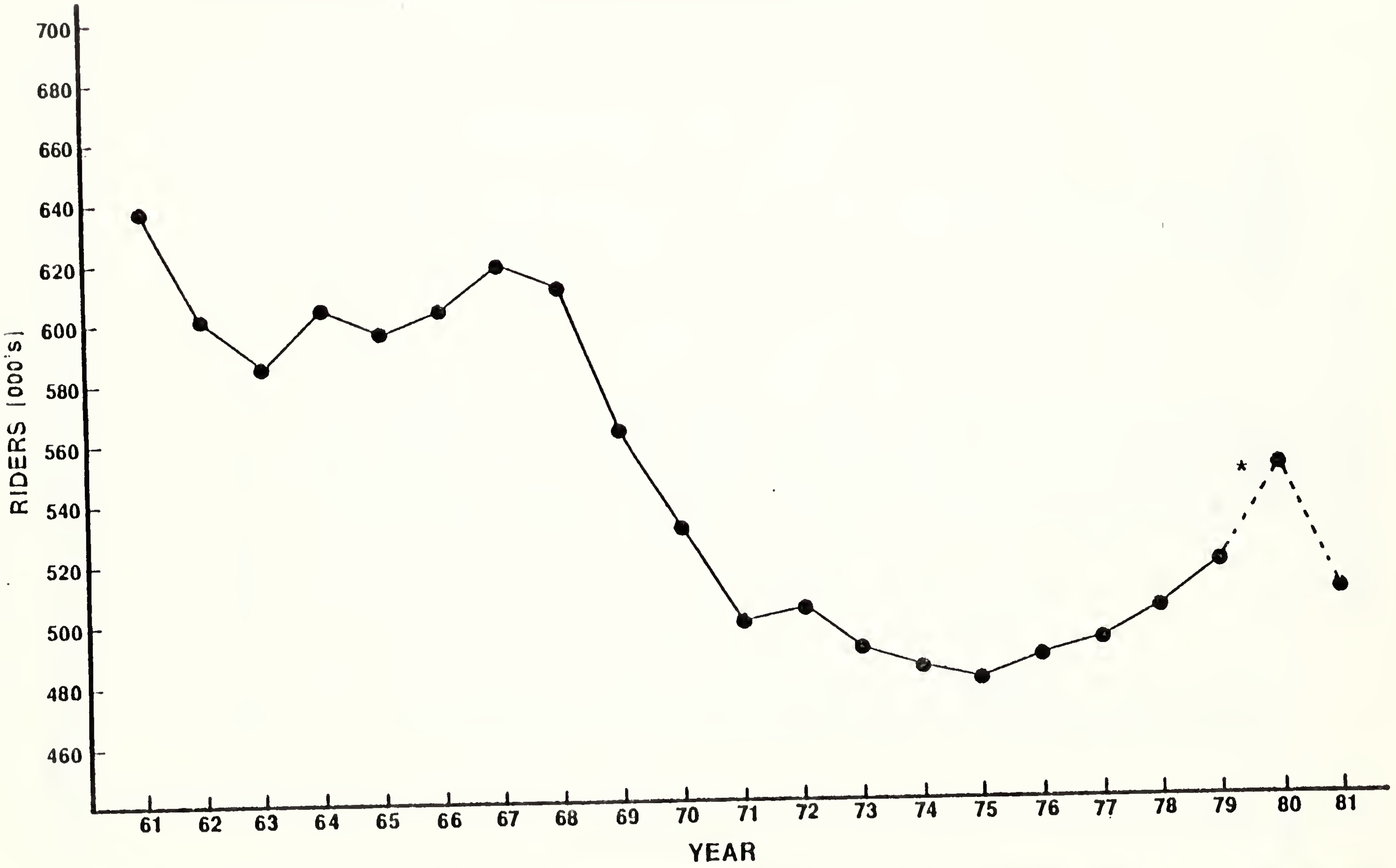
Ridership Levels on the MBTA
(1951-1981)

Year	Annual Ridership	Annual Average Weekday Ridership
1951	289,000,000	966,000
1952	278,000,000	930,000
1953	268,000,000	896,000
1954	244,000,000	816,000
1955	225,000,000	753,000
1956	219,000,000	732,000
1957	212,000,000	709,000
1958	206,000,000	689,000
1959	202,000,000	676,000
1960	200,000,000	669,000
1961	190,000,000	636,000
1962	180,000,000	602,000
1963	175,000,000	585,000
1964	181,000,000	605,000
1965	178,000,000	595,000
1966	181,000,000	605,000
1967	185,000,000	619,000
1968	183,000,000	612,000
1969	168,000,000	562,000
1970	158,000,000	528,000
1971	149,000,000	500,000
1972	150,000,000	503,000
1973	146,000,000	489,000
1974	144,500,000	483,000
1975	143,500,000	480,000
1976	145,700,000	487,000
1977	146,700,000	491,000
1978	151,400,000	506,000
1979	155,600,000	520,000
1980*	163,450,000	545,000
1981*	153,260,000	511,000

SOURCE: MBTA
*Not directly comparable because derived using a different method.

Ridership Levels on the MBTA
(1951-1981)

TABLE 2-3



*Not directly comparable; derived using different method.

MBTA ESTIMATED AVERAGE WEEKDAY RIDERSHIP

FIGURE 2-5

a value may be derived in several ways. The figures presented in Table 2-3 give an indication of trends in ridership derived in this manner over the last 30 years.

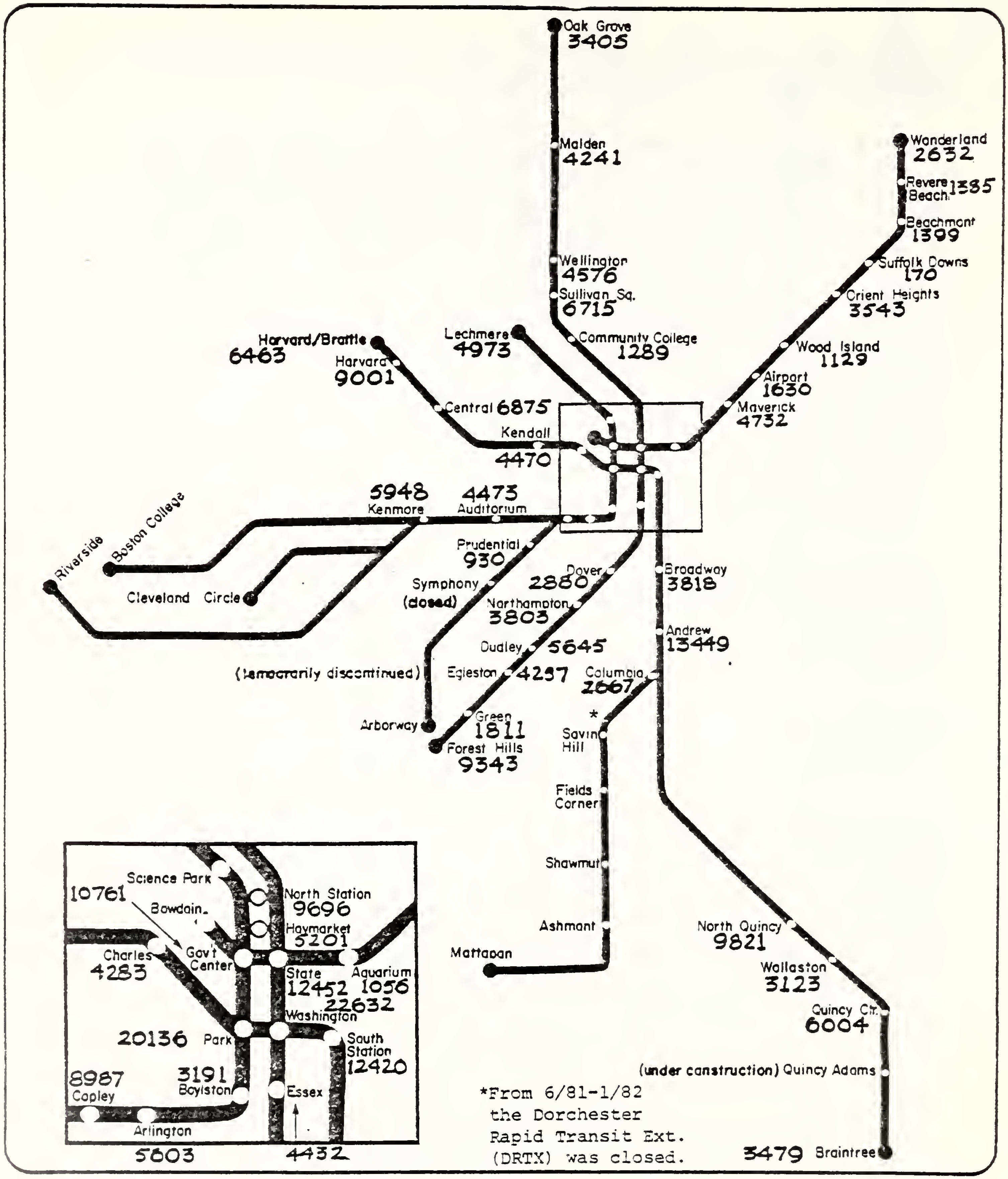
With the fare changes made in 1980 and 1981, it was felt that the mix of rider types and, thus, the average fare value may have changed. It was assumed that the ridership response of those paying lower fares, i.e., the elderly, would cause the average fare to be substantially lower than one might expect from the corresponding increase in the fare. In an attempt to correct for this, the 1980 ridership estimates have been derived by using all available revenue sources and making adjustments based on the number of linked and unlinked trips found in the 1978 Wilbur-Smith Survey of MBTA ridership. As a result, ridership estimates for 1980 are not directly comparable to previous estimates, due to changes in estimation techniques. In 1981, a fare-mix sampling program was initiated by the MBTA to estimate the new fare mix which occurred as a result of the fare increase. This sampling program and its results will be presented in a further discussion of ridership estimation and the steps the MBTA is taking to improve these estimates provided in Appendix B and in Section 7.1.2 concerning mitigating measures.

Ridership on public transportation in the Boston area has dropped significantly over the past three decades, declining from almost one million trips per day in 1950 to approximately one half that amount in 1982. Ridership declined steadily until the early 1960's when it stabilized at roughly 600,000 trips per average weekday.

This trend has occurred in mass transit systems across the United States and has generally been attributed to such factors as increasing affluence and accompanying automobile ownership, growing suburbanization, and widespread highway construction.

In the early 1970's, average weekday ridership was as low as 480,000 trips. The time period from 1976 to 1980 showed an indication of a possible reversal of this declining trend. Factors which may have influenced this increase in ridership include the rising cost of gasoline, constraints on its availability, and the expansion of transit services into suburban areas. With the fare increases of 1980 and 1981 and an accompanying series of service reductions, however, trips have dropped back to the levels seen in the early 1970's. This trend is evident on each of the rapid transit lines in the system. Figure 2-6 displays boardings by station for an average weekday in November 1981.

In 1980, the Green Line carried the greatest proportion of riders (39 percent) on rail transit lines.* The Blue Line carried the fewest number of passengers (22,700), representing only 8 percent of all transit riders. The Red Line carried almost one third, and the Orange Line 21 percent of these trips. These proportions



*From 6/81-1/82 the Dorchester Rapid Transit Ext. (DRTX) was closed.

RAPID TRANSIT RIDERSHIP BY STATION
NOVEMBER 13, 1981

Figure 2-6

have shown variation over time but generally have stayed within a few percentage points of these values. The number of riders on each line are given in Table 2-4 for 1950-1980.

The commuter rail ridership levels are shown in Table 2-5. the most recent trend is an increase in the number of trips (+20 percent) over the past few years, despite fare hikes during that time. The increase has been evident on all lines with the exception of the Reading Line.

Bus ridership has dropped over time; however, information to attribute these losses to specific routes is not available. Furthermore, bus service has been changed in response to demand generated by new activity centers, residential areas, or other factors, making a direct comparison inappropriate.

2.4 CHRONOLOGY OF CHANGES IN MBTA SERVICE LEVELS AND FARES

Efforts have been made to alleviate financial problems by altering both the level of service provided and the cost of transit fares. Since late in 1979, three major service decreases have been instituted, with the most significant change being made during the winter timetable (beginning in January) of 1981. From April 1981 until June 1982, there has been a phased restoration of service with previous levels of service nearly restored by the commencement of the Summer 1982 Timetable. Also during this time period, the base cost of a rapid rail fare was raised from 25 cents in 1979 to 50 cents in 1980, and later to 75 cents in 1981. The estimated impacts of this fare increase are the subject of much of the remainder of this report. In the spring of 1982, a further revision was made in the rapid transit base fare when it was reduced to 60 cents. Table 2-6 details the chronology of the service and fare changes made during this time period.

2.4.1 Recent Service Level Changes

A detailed examination of the cuts made in the beginning of the winter of 1981 follows. Facing financial problems, the MBTA Board of Directors adopted a revised schedule with service changes aimed at reducing surface manpower requirements by 20 percent (or approximately 300 surface operators). This set of service reductions, concentrating on the high cost and low ridership MBTA-run and MBTA-subsidized transit services, was initiated during the first quarter of 1981. Specific actions proposed and implemented by the Board of Directors included:

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*These proportions do not include boardings at the six transfer stations in downtown Boston.

Year	Six Downtown Transfer Stations	Red Line	Orange Line	Blue Line	Green* Line	Total
1950	198,400	196,100	213,200	36,400	186,600	830,700
1951	185,900	189,400	207,000	34,500	178,900	795,700
1952	182,200	179,200	194,200	38,500	175,400	769,500
1953	172,600	181,100	187,300	37,400	168,300	746,700
1954	180,600	175,800	178,600	37,000	165,600	737,600
1955	159,200	159,700	157,600	33,300	151,300	661,100
1956	154,800	153,100	150,800	33,500	148,300	640,500
1957	163,100	147,900	150,800	32,900	148,400	643,100
1958	142,100	143,300	144,100	31,900	144,200	605,600
1959	146,000	151,300	141,300	31,200	152,000	621,800
1960	140,000	143,400	139,000	30,200	151,700	604,300
1961	126,600	109,800	97,300	28,300	120,200	482,200**
1962	120,900	105,500	90,100	27,000	111,000	454,500
1963	120,900	105,000	89,100	25,800	111,800	452,600
1964	111,200	103,900	86,100	25,700	115,000	441,900
1965	110,000	105,000	84,700	26,600	121,900	448,200
1966	119,900	109,800	84,600	26,800	127,200	460,300
1967	121,000	114,000	83,000	25,200	125,300	468,500
1968	109,200	105,000	74,300	25,700	118,500	437,700
1969	115,700	104,500	78,000	27,600	119,100	444,900
1970	112,400	100,800	70,000	27,500	113,400	424,100
1971	116,600	108,700	70,800	28,400	112,900	437,300
1972	104,600	109,400	67,200	25,400	109,500	416,100
1973	104,000	105,900	62,500	28,200	103,100	403,800
1974	100,300	111,100	58,200	25,200	102,700	397,400
1975	96,900	103,400	57,100	22,100	105,500	385,100
1976	100,500	99,600	53,400	23,500	104,800	381,900
1977	93,200	106,100	59,200	23,600	112,300	394,900
1978	111,800	110,500	65,300	24,200	116,400	428,000
1979	109,400	116,800	61,900	28,100	127,400	443,400
1980	88,800	103,500	59,400	22,700	113,800	388,300

Source: MBTA, Office of Service Planning

*Includes surface portions of the Green Line.

Counts are typically taken in the first week of December.

**In 1961, transfers from surface riders to rapid transit were no longer used and thus were no longer counted as a portion of rail transit riders.

NUMBER OF RAIL TRANSIT RIDERS PER AVERAGE WEEKDAY

TABLE 2-4

Year	Total	Eastern Line	Reading Line	New Hampshire Line	Fitchburg Line	Bedford Line	South Sudbury Line
1966	20,010	4,560	7,090	5,330	2,550	230	250
1967	20,760	5,620	6,770	5,370	2,530	230	240
1968	19,580	5,290	6,450	4,920	2,570	190	160
1969	19,070	5,250	6,380	4,560	2,530	200	150
1970	20,200	5,290	6,430	5,690	2,440	190	160
1971	20,240	5,090	6,450	5,800	2,460	190	250
1972	19,670	5,500	5,830	5,800	2,410	130	
1973	17,610*	4,660	5,430	4,870	2,540	110	
1974	**	-	-	-	-	-	-
1975	16,840*	4,870	5,030	4,700	2,120*	120	
1976	16,370*	4,740	4,570	4,120*	2,940	90	
1977	16,530	5,370	4,380	4,020	2,760	*	
1978	-	-	-	-	-	-	-
1979	17,560	5,590	4,150	4,520	3,300		
1980	19,000	6,690	4,190	3,910	4,210		
1981	19,560	7,010	4,420*	4,270	3,860		

SOUTHERN DIVISION

Year	Total	Needham	Framingham	Franklin	Rhode Island	Stoughton
1966	11,000	NOT AVAILABLE BY LINE [Penn. Central]				
1967	10,900					
1968	10,500					
1969	9,900					
1970	9,600					
1971	8,900					
1972	8,300					
1973	9,200					
1974	10,500	2,730	1,210	2,030	1,960	2,570
1975	10,700					
1976	11,200					
1977	12,990	3,240	1,420	2,630	2,460	3,240
1978	12,300					
1979	13,900	2,600	1,550	2,980	2,930	3,840
1980	14,930	***	3,140	3,820	3,940	4,030
1981	15,890		3,010	4,550	3,520	4,310

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*Represents a major service change.

**Not available.

***Bus replacement.

Source: 1966-1973 - Northern Division, B&M Audit Summaries; 1966-1973 - South Division, Penn Central; 1974-1981 - MBTA Audits.

COMMUTER RAIL AVERAGE WEEKDAY RIDERSHIP (1966-1981)
NORTHERN DIVISION

TABLE 2-5

November, 1979	• Bus Service Cuts Peak Vehicle Requirements reduced by 50 buses
July, 1980	• RTL Fare Increase Base fare increased from 25¢ to 50¢
Winter, 1981	• Sunday Bus Service Cuts • RTL Station Closings • Commuter Rail Service Reduction • Downtown Crossing Service Terminated
April, 1981 (Spring Timetable)	• Bus Service Cuts 18% of weekday trips terminated • Sunday Service Hours reduced Rail: 6:00 AM - 11:00 PM Bus: 7:00 AM - 7:00 PM
June, 1981	• DRTX closed for reconstruction
August, 1981	• Systemwide Fare Increase RTL Base Fare increased from 50¢ to 75¢ Bus Base Fare increased from 25¢ to 50¢
September, 1981 (Fall Timetable)	• Sunday Bus Service Hours extended to 11:00 PM • Bus Service Improvement/Restoration on 30 routes
January, 1982 (Winter Timetable)	• Bus Service Improvement/Restoration on 12 routes • Bowdoin Station Reopened • DRTX reopened.
May, 1982 (Spring Timetable)	• RTL Fare Reduction Base fare decreased from 75¢ to 60¢ • Downtown Crossing Service Restored • Bus Service Improvement/Restoration on 12 other routes • Sunday Evening Service Hours extended to 1:00 AM on all modes • RTL and Green Line Headway Improvements
June, 1982 (Summer Timetable)	• Arborway Streetcar Service Restored • Symphony Station Reopened

CHRONOLOGY OF MBTA SERVICE LEVELS AND FARES

TABLE 2-6

- Curtailing Sunday late evening service on rapid transit, streetcar, trackless trolley, and bus routes, providing a total of 12 hours of Sunday service.

- Closing Bowdoin and Symphony stations on the rapid transit lines.

- Discontinuing Sunday daytime service (only) on 60 bus routes.

- Reducing or eliminating subsidies for local bus services.

Furthermore, to accomplish the cutbacks in service, the Office of Service Planning developed a set of basic guidelines and methods for instituting emergency bus service reductions which included: (1) the elimination of bus routes, (2) the elimination of route segments, (3) the increasing of headways (reducing the frequencies of trips) especially during peak periods, (4) the reduction of the hours during which bus service is provided, and (5) changing the express bus services provided. Service changes included:

- Changing the headways or making other schedule reductions for more than 106 bus routes.

- Discontinuing 28 bus routes entirely.

- Combining 3 pairs of bus routes.

- Discontinuing route segments in 15 bus routes.

- Discontinuing 2 bus routes during off-peak periods.

Of all bus routes, 88 percent had some changes made in scheduled headways. These alterations were made largely as the result of a policy decision to raise the peakload standards from 140 percent of designed seating capacity to 160 percent during the peak 30 minutes for all bus routes. A display of the vehicle assignments before and after the service changes may be found by comparing Table 2-2 (A) with Table 2-2 (B).

In addition, changes were made by the Commuter Rail Department which included:

- Closing 9 of the commuter rail stations on 6 branches.

- Instituting a 9.7 percent cut in the total number of commuter rail trains operated.

Beyond scheduled reductions in service, there has also been a change in the quality of service and dependability. In 1979, a systemwide average of 96 percent of all scheduled trips were made. Of those trips not made, 11 percent of the time the cause was due to a lack of available crew to make the trip. In 1980, a systemwide average of 97 percent of all scheduled trips were made.

In 1981, average weekday service saw an average of 97 percent of all scheduled bus trips run (see Table 2-7A) and 95.77 percent of all rapid transit trips run (see Table 2-7B). On a systemwide level, an average of 96.9 percent of all scheduled trips were made in 1981. Obviously, this is not a significant change from previous years; however, what is significant is that 40.3 percent of all trips not made (44 percent for rapid transit, 39 percent for buses) occurred due to a lack of personnel. Accompanying a reduction of all scheduled trips, the vehicle availability and the condition of those vehicles used was improved due to the increase in total vehicles available for trips to be made.

There are several reasons for trips not being made, principally disabled vehicles, lack of vehicles, or lack of available crew members. A significant factor in the issue of crew availability which has accompanied other major service cuts, has been a reduction in the "cover list" of available drivers. This list of vehicle operators is a pool of additional manpower used to fill in for staff who are ill, on jury duty, or personal leave, or who retire or resign in the middle of a timetable. (Presently, hiring is conducted at the start of each new timetable (quarterly)).

Historically, the cover list was maintained at 14 percent (of scheduled runs) in excess of the drivers needed for scheduled operations. In September of 1979, this percentage was altered to 12 percent, and in April of 1981, it was further reduced to 9 percent. A 9 percent cover list appears to create a scarcity of cover personnel, especially by the end of a given timetable at which point the actual percentage of cover personnel has dropped to near zero.

The results of this lack of cover personnel become a type of service reduction. Table 2-8A shows, for example, that of all 1981 average weekday bus trips scheduled but not made, 39 percent failed to occur due to a shortage of crew. This is 1 percent of daily total trips. Table 2-8B shows the same data for the rapid transit system.

During the course of 1981, a number of the instituted service reductions were "discontinued," thereby restoring previous levels of service. By February of 1982, more than half of the bus routes affected had been at least partially restored to previous service levels with the major restoration of service having occurred in April of 1981. Sunday evening service has been restored as have many of the other types of reductions in conjunction with the 1981 fare increase. It is estimated that original cuts made in the beginning of 1981 reduced service, as measured by vehicle miles, by 20 percent. The MBTA estimates that total service reduction in November of 1981 is between 12 percent and 13 percent of the bus service provided in 1980.

Garage	Scheduled[1] Trips	Trips[1] Run	Percentage of Trips Run
Cabot	2,301	2,224	96.52%
Arborway	1,473	1,444	97.60%
Quincy	614	604	98.35%
Bennett Street	873	840	95.96%
Salem	1,241	1,218	97.77%
Lynn	619	609	98.20%
TOTAL	7,121	6,939	97.20%

[1] Included school trips.

Source: 1981 MBTA Service Tracking Reports Annual Report.

TABLE 2-7A

1981 AVERAGE WEEKDAY SERVICE PERFORMANCE BY BUS GARAGE (JANUARY-DECEMBER)

Line	Scheduled Trips	Trips Run	Percentage of Trips Run
Red Line	743	691	93.00%
Orange Line	498	489	98.15%
Blue Line	533	525	97.51%
Green Line*	726	694	95.55%
Mattapan	169	163	96.30%
TOTAL	2,675	2,562	95.77%

Source: 1981 MBTA Service Tracking Reports Annual Report.

*Does not include Northeastern University/ Brigham Circle trips.

TABLE 2-7B

1981 AVERAGE WEEKDAY SERVICE PERFORMANCE (JANUARY-DECEMBER) BY RAPID TRANSIT LINE

Garage	Total Trips Not Run	Vehicles[1] Not Available	Percentage of Vehicles Not Available	Crew Not Available	Percentage of Crew Not Available	Disabled[2] Vehicles	Percentage of Disabled Vehicles	Miscellaneous[3]	Percentage of Miscellaneous
Cabot	80	17	21%	34	2%	25	32%	2	2%
Arborway	35	2	6%	17	49%	7	19%	3	10%
Quincy	10	*	*	4	42%	3	28%	1	12%
Bennett Street	35	17	49%	7	20%	6	18%	3	9%
Salem	28	4	15%	10	35%	6	22%	3	13%
Lynn	11	*	*	5	44%	5	42%	0	2%
TOTAL	199	41	20%	77	39%	52	26%	12	7%

Data represents average annual weekday.

[1] Vehicles not available for a particular run due to breakdown on a previous run or to mechanical problems that require light repair work.
[2] Run started but not completed because of vehicle malfunction.
[3] Includes runs not made because of weather.

Source: MBTA Service Tracking Reports Annual Report, 1981**.

*Absolute number of less than .5 percent $\leq .02$.
**Note that in the report, trips not run include school trips not run because of school vacations, holidays, snowdays, and rescheduled hours. These trips are not reflected in the above table.

TABLE 2-8A

1981 AVERAGE WEEKDAY BUS TRIPS NOT RUN

Line	Trips Not Run	Vehicles[1] N/A	Percentage of Vehicles N/A	Crew N/A	Percentage of Crew N/A	Disabled[2] Vehicles	Percentage of Disabled Vehicles	Headway	Percentage of Headway	Miscellaneous[3]	Percentage of Miscellaneous
Red Line	52	17	32%	12	23%	12	23%	11	21%	*	*
Orange Line	9	*	8%	6	67%	*	3%	*	9%	1	11%
Blue Line	13	*	*	9	69%	*	4%	2	15%	1	8%
Green Line	32	10	31%	19	59%	2	7%		0%	1	3%
Mattapan	6	1	17%	4	56%	1	19%		0%	*	*
TOTAL	113	29	25%	50	44%	16	14%	13	12%	5.0	4%

[1] Vehicles not available for a particular run due to a breakdown on a previous run or to mechanical problems.
[2] Run started but not completed because of vehicle malfunction.
[3] Includes runs not made because of weather.

Source: MBTA Service Tracking Reports, 1981.

*Absolute number of less than .5 percent $\leq .02$.

TABLE 2-8B

1981 AVERAGE WEEKDAY RAPID TRANSIT TRIPS NOT RUN (JANUARY-DECEMBER)

2.4.2 Fare Levels on the MBTA

Historic Fare Levels and Structures

Base fares on the MBTA system changed very slowly in the three decades prior to 1980. bus fares went from 10 cents in 1950 to 25 cents in 1980, with 5 cent increases in 1954, 1968, and 1975 (an average increase of one half cent per year). Rapid transit fares went from 15 cents in 1950 to 20 cents in 1954 and then to 25 cents in 1968 (an average increase of one third cent per year). Over this time period, several other changes were made in the fare system. The most significant change was the elimination of free transfers between subways and buses which began in 1961. In 1969, the state passed legislation providing a reduced fare to citizens over the age of 65 who reside in the MBTA district. Dime Time, an experimental program that reduced rapid transit fares to 10 cents between 10 AM and 1 PM, Monday through Friday, was in effect between 1973 and 1975.*

Current Fare Levels and Structure

In 1980, the MBTA began to make additional changes in the fare structure. In July, rapid transit fares increased 25 cents; combined trips on the subway and the Arborway, Commonwealth Avenue, or Beacon Street lines increased by 5 cents (see Figure 2-7). commuter rail fares were raised an average of 19 percent. Rapid transit fares had not been raised since 1968; railroad fares were last raised in 1975.

In August 1981, the MBTA initiated a systemwide fare increase. The local bus fare went from 25 cents to a zonal system with a 50 cent base fare. The base rapid transit fare rose from 50 cents to 75 cents. Express bus fares also increased to a maximum of $1.50/trip. This fare structure is shown in Figure 2-8 for rapid transit and Table 2-9 for buses. Senior citizens are allowed to ride free between 9:30 AM and 4:00 PM on weekdays. Students are offered fares at half the adult full fare. At the same time, the cost of prepaid passes, good on combination bus to rapid transit trips, was changed to reflect the base cost of 16 round trips instead of 18 round trips.

In 1982, in response to decreased ridership, due in part to the higher fares, the MBTA adjusted the rapid transit fares once again. The base fare price, beginning in May 1982, was lowered from 75 cents to 60 cents and the fares on surface transit were retained using the zonal breakdown to determine cost.

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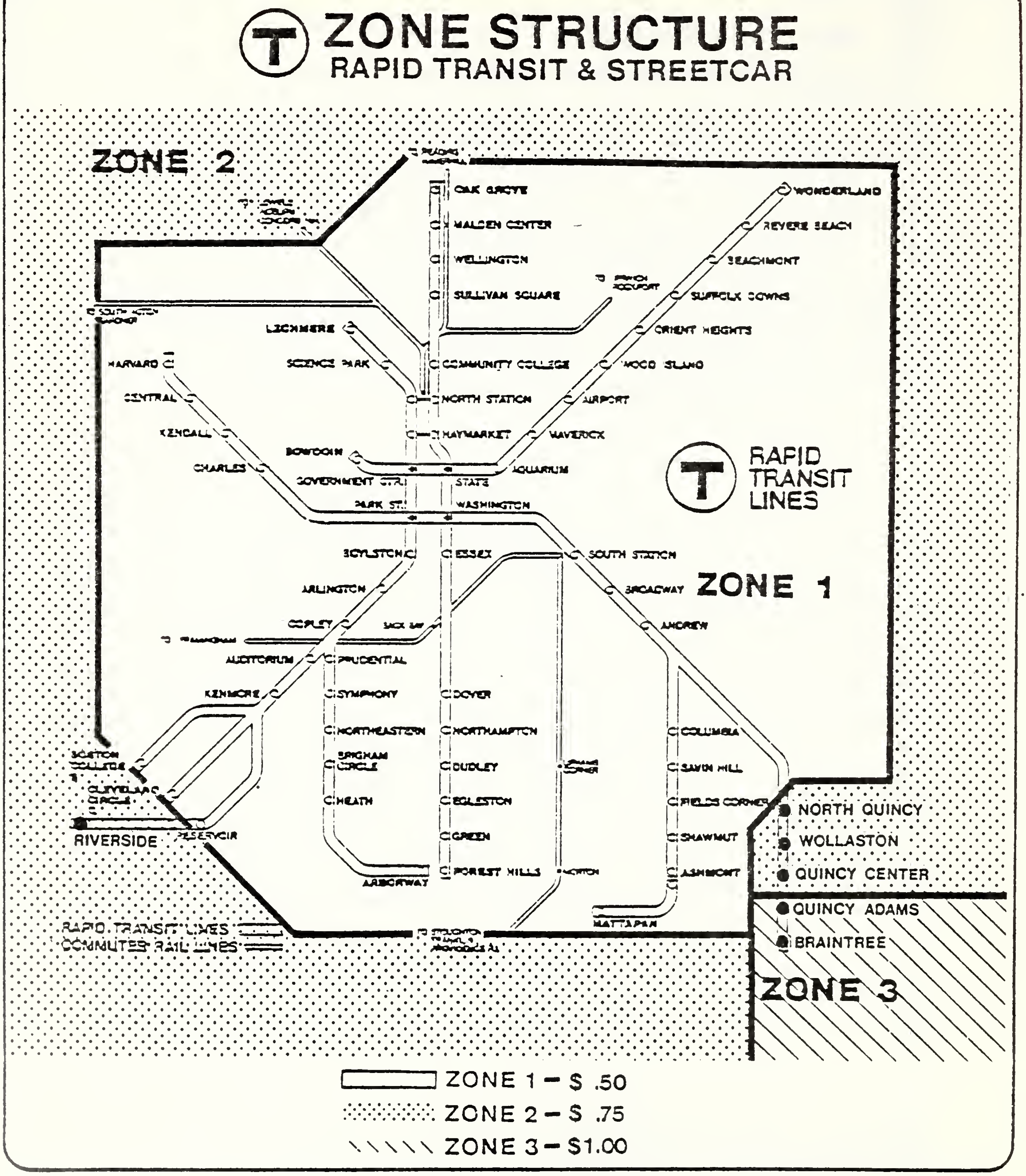
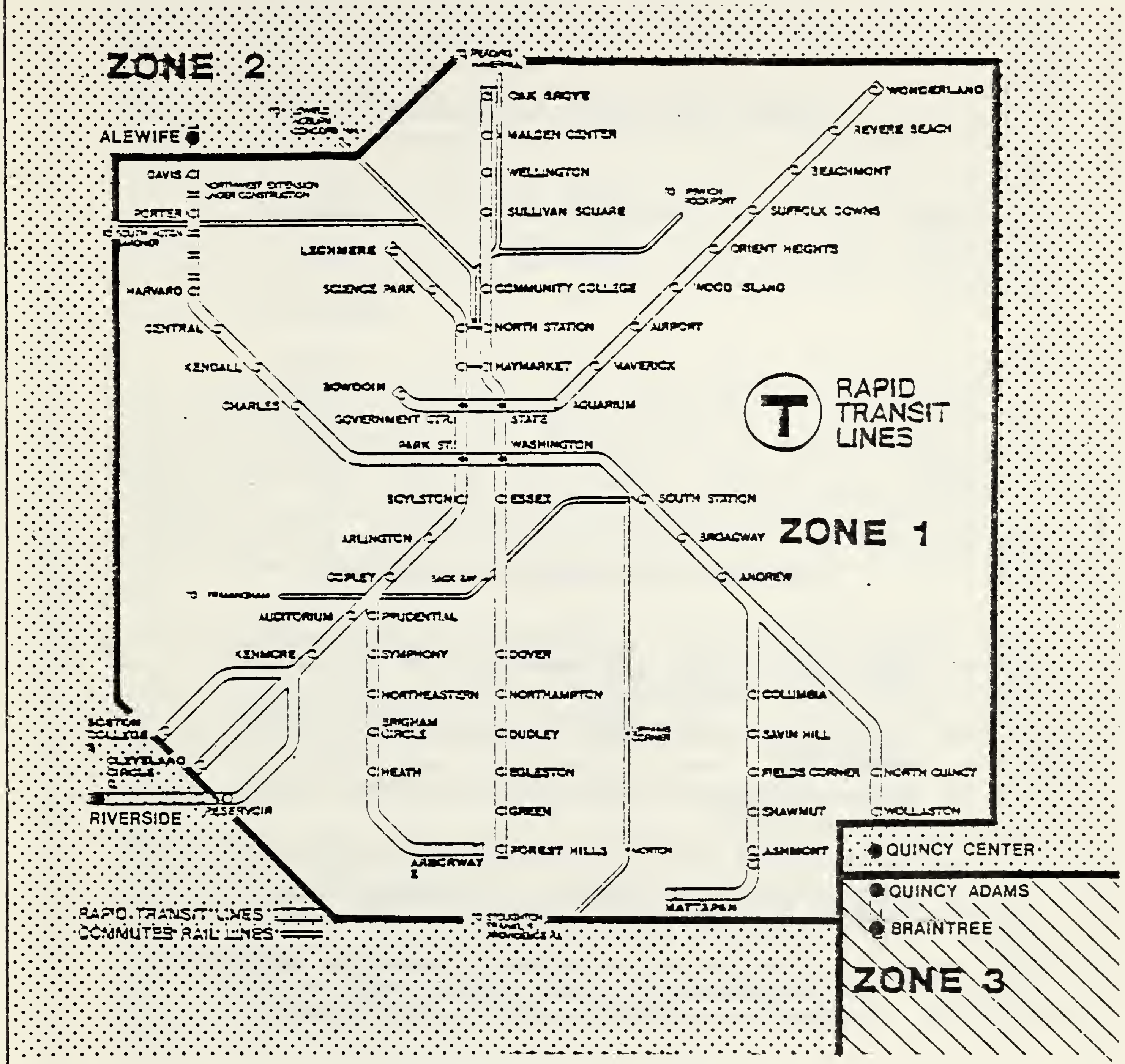
*Dime Time was extended until 2 PM in 1974 in an effort to increase off-peak ridership. The program is discussed more fully in Section 5.0.



1980 FARE STRUCTURE

Figure
2-7

ZONE STRUCTURE
RAPID TRANSIT & STREETCAR



▭ ZONE 1 - $ .75

▒ ZONE 2 - $1.12½ OR $1.125 EACH WAY

▨ ZONE 3 - $1.50

1981 FARE STRUCTURE

Figure 2-3

Zonal Fare Tariff - Bus System

Zone	Route Miles	Fare
1	0 - 6	$0.50
2	6 - 9	0.75
3	9 - 12	1.00
4	12 - 15	1.25
5	15 +	1.50

Categories, Fare Tariff - Bus System

- Base Fare - $0.50, good for all routes that are less than 6 miles and for the first 6-mile zone on routes longer than 6 miles
- Zone Fares - Additional $0.25 for each 3-mile increment.
- Express Premium - Additional $0.25 for express bus services.
- Maximum Fare - $1.50, including express premium.
- Senior Citizen, Children, and Student Fares - Consistent with rapid transit fare policy.

NOTE: Zone Fares may be adjusted based on geographic, topographic, or other unusual conditions in order to establish logical zone boundaries.

CHANGES IN BUS FARES, AUGUST 1981

TABLE 2-9

Analysis of Change in Fares

Changes in the real cost of transit in Boston cannot be understood solely on the basis of changing base fares. The true cost of transit reflects the changing relationship between the base fares and the average fare and also the impact of inflation. The base fares represent an accurate picture of the cost of transit for riders who use a single mode and obtain no discounts from passes or special fares. Due to discounts offered to various groups of riders, however, an average fare is more meaningful for comparisons. For instance, the use of prepaid discount passes has increased dramatically in recent years. The elderly have gone from paying full fare to paying half fare beginning in 1969, to less than half fare in 1980, and finally to free during the off-peak beginning in 1981 and 1982. Prior to 1961, transfers from bus-to-subway were free; now riders who link trips must pay fares on both modes.

For these reasons, an average fare has been calculated to facilitate comparisons. The 1980, 1981, and 1982 figures are not directly comparable to those prior to 1980, due to changes in estimation techniques. The average fare is calculated by estimating the amount paid by each transit rider for a complete linked trip. The reduced fares for the handicapped, elderly, and students, and the increased use of passes, have caused the average fare to become a smaller and smaller percentage of the total linked trip base fare ever since transfers were abolished in 1961.

Although fares have been increasing in an absolute sense, the value of money has fallen dramatically. Figure 2-9A shows the average fare plotted in both current and constant 1967 dollars. When inflation is taken into account, it is evident that the average fare fell dramatically between 1969 and 1979. Even when the 1980 and 1981 fare increases are taken into account, the real average fare in 1982 is lower than it was between 1969 and 1972.

Figure 2-9B shows fares plotted against inflation and the price of gasoline, using 1967 as an index = 100 for each of the variables.* Since 1974, the indexed cost of gasoline has increased faster than the Consumer Price Index (CPI) and MBTA fares. Gasoline is considered in this analysis, since it represents a major component of the cost of automobile use, an alternative mode of travel to public transportation. It, therefore, plays an important role in determining the impacts of an increase in the fares on the MBTA.

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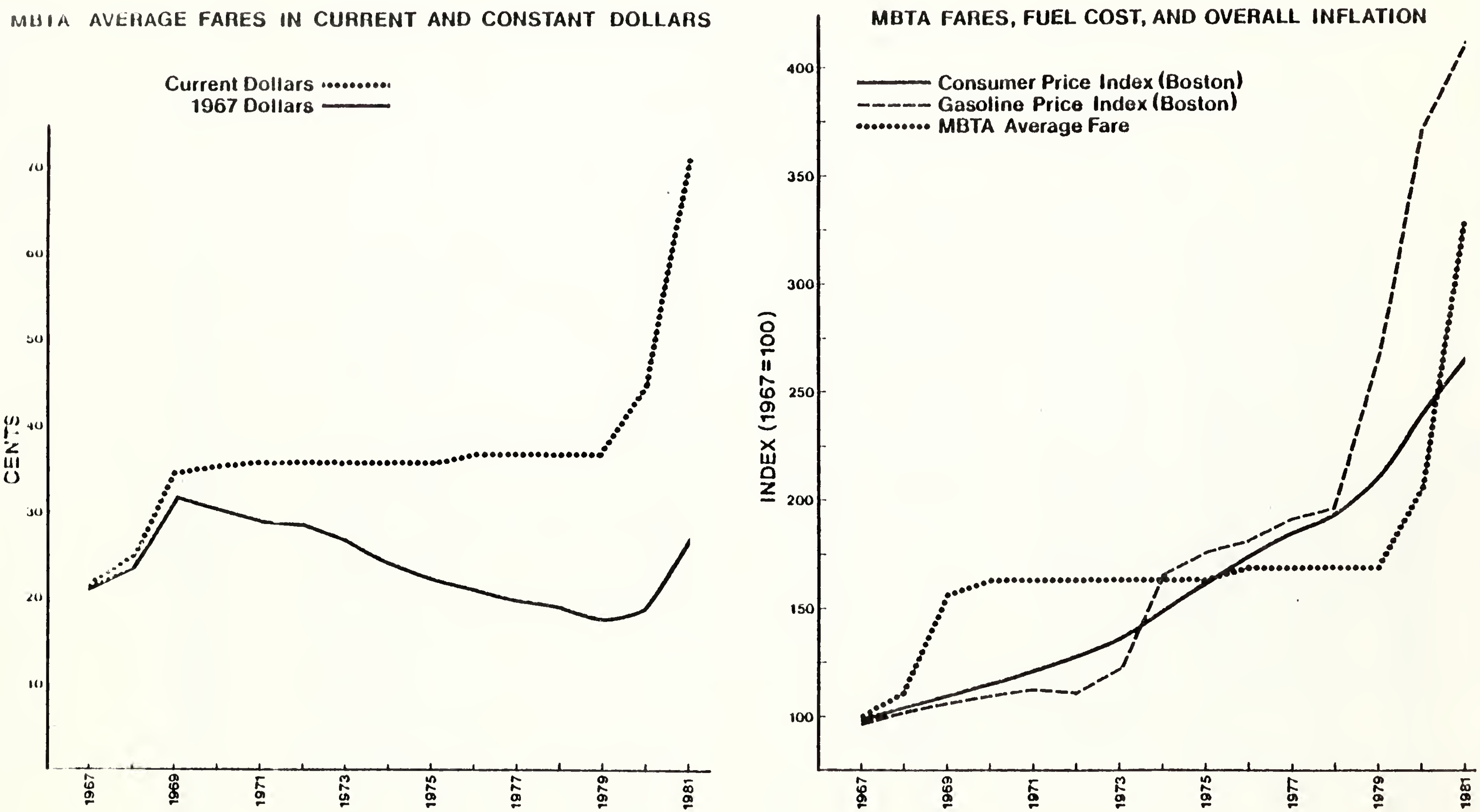
*The CPI is developed using a base of 100 for 1967. The two other variables, fares and gasoline, were indexed also to 1967.



MBTA AVERAGE FARES IN CURRENT AND CONSTANT DOLLARS

MBTA FARES, FUEL COST, AND OVERALL INFLATION

TRENDS IN MBTA FARES

FIGURE
2-9
A+B

2.5 COST OF MBTA SERVICE

The cost of providing MBTA service can be described in two broad categories: operating expenses and capital expenses. Capital expenses are funds spent for improvements or additions to the physical plant or equipment. Eighty to eighty five percent of capital expenses are financed with federal (Urban Mass Transportation Administration) funds. The remaining fifteen to twenty percent of capital expenses are financed through the issuance of long-term bonds. The interest and principal on these bonds are paid by the MBTA, and represent a fixed cost in the annual budget. With increasing capital expenditure in recent years, these fixed costs have become a greater component of the annual budget.

Operating expenses are those recurring costs in the transportation system, such as salaries and wages, maintenance, energy, taxes, interest on unfunded debt, insurance, and supplies. Operating expenses can be divided into two categories: MBTA operations and private carrier contract costs. Under terms of contracts with private carriers, such as the Boston and Maine Railroad and Rapid Transit Incorporated, the MBTA pays for the cost of service not covered by fare revenue. This net cost of service appears in the MBTA budget. For the purpose of this analysis, only the costs of the MBTA-run system will be considered as operating expenses.

Table 2-10 and Figure 2-10 display trends in average fare and operating costs from 1967 to 1981 in both real and current terms. Operating costs and revenue from transportation are summarized in Table 2-11.

Overall, the fares charged by the MBTA do not cover the cost of providing transit service. Passenger revenue, which in 1970 covered over 50 percent of the cost of operating the MBTA, accounted for less than 26 percent of the cost of operations in 1980. This trend has recently been reversed, with passenger revenue covering 31 percent of operating costs in 1981.

Adjusting for inflation (1967 dollars), operating cost per passenger in 1980 was 66 cents, with the average fare per passenger at 16.7 cents. The difference between the cost and fare has lessened in 1981, with the real operating cost per passenger at 64 cents, and the real average fare per passenger at 20.9 cents.

The cost per mile of operation of the MBTA is higher than the cost/mile of operation experienced by other transit authorities. This cost/mile value for other transit authorities is shown in Table 2-12. It must be noted that different transit authorities employ different accounting procedures and may consider different formulas for calculating costs (for example, not including

Year	Average Fare Per Passenger		CPI	Cost Per Passenger(3)		Cost Per Mile(4)		Percent of Costs Covered by Passenger Revenue(5)
	Current Value(1) (Cents)	Real Value(2) (Cents)		Current Dollars	Real Dollars	Current Dollars	Real Dollars	
1967	21.7	21.7	1.000	0.36	0.36	1.75	1.75	65.1
1968	24.3	23.4	1.038	0.42	0.40	1.78	1.71	63.2
1969	34.3	31.2	1.099	0.55	0.50	2.03	1.84	68.5
1970	35.3	30.2	1.169	0.69	0.59	2.43	2.08	55.8*
1971	35.7	29.0	1.231	0.74	0.60	2.71	2.21	47.7**
1972	35.8	28.2	1.270	0.83	0.65	2.96	2.33	43.2
1973	35.8	26.5	1.351	0.92	0.68	3.28	2.43	38.7
1974	35.7	24.0	1.488	1.08	0.73	3.81	2.56	32.9
1975	35.7	22.0	1.623	1.19	0.73	4.15	2.56	30.0
1976	36.4	20.9	1.742	1.21	0.69	4.48	2.57	29.9
1977	36.4	19.9	1.829	1.31	0.71	4.96	2.70	28.0
1978	36.5	18.9	1.931	1.33	0.69	5.30	2.75	27.4
1979	36.5	17.3	2.110	1.45	0.69	5.89	2.79	25.1
1980	40.5***	16.7	2.425	1.57	0.66	6.50	2.72	25.7
1981	55.8***	20.9	2.666	1.71	0.64	7.35	2.76	31.2

(1) Represents average fare paid throughout the year

(2) Real value represents 1967 dollars; real average fare equals average fare divided by CPI.

(3) Operating expenses divided by total passengers; operating expenses are for all MBTA-operated services excluding subsidized and privately-owned carriers.

(4) Operating expenses divided by total revenue miles; operating expenses are for all MBTA-operated service excluding subsidized and privately-owned carriers.

(5) Transportation revenue divided by operating expenses.

*First full year of Eastern Massachusetts Service.

**Opening of the South Shore Red Line.

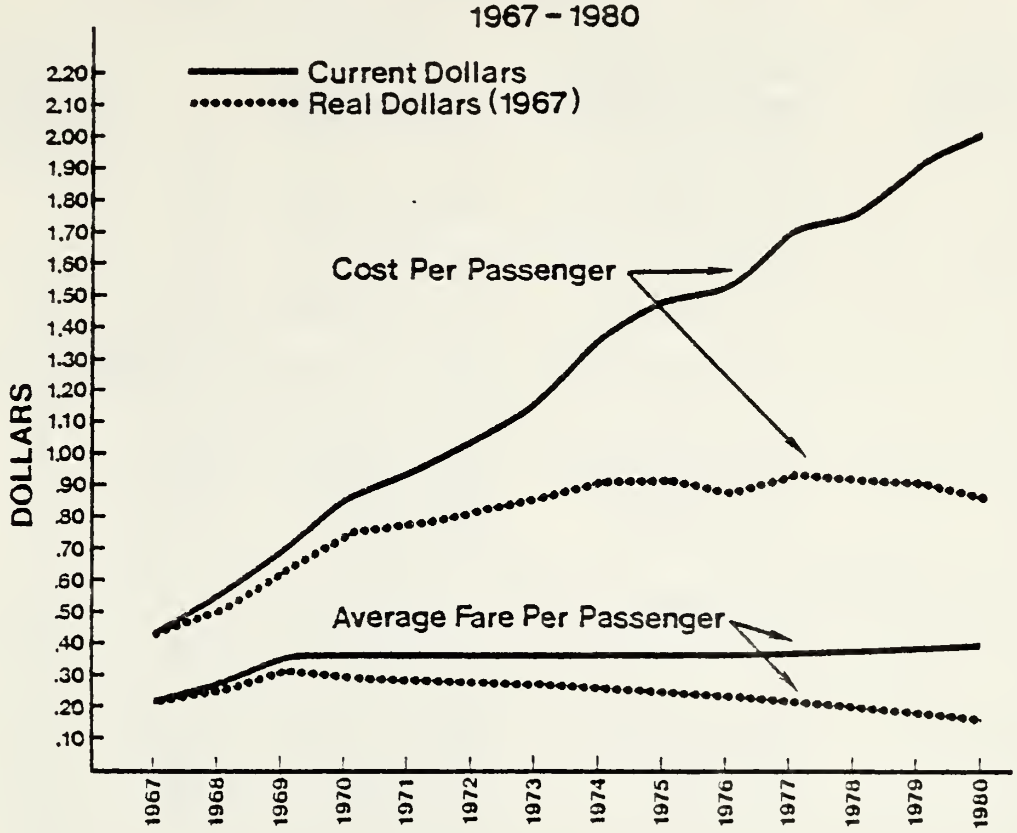
***Not directly comparable; derived using a different method.

Source: MBTA Treasurer's Office; CTPS.

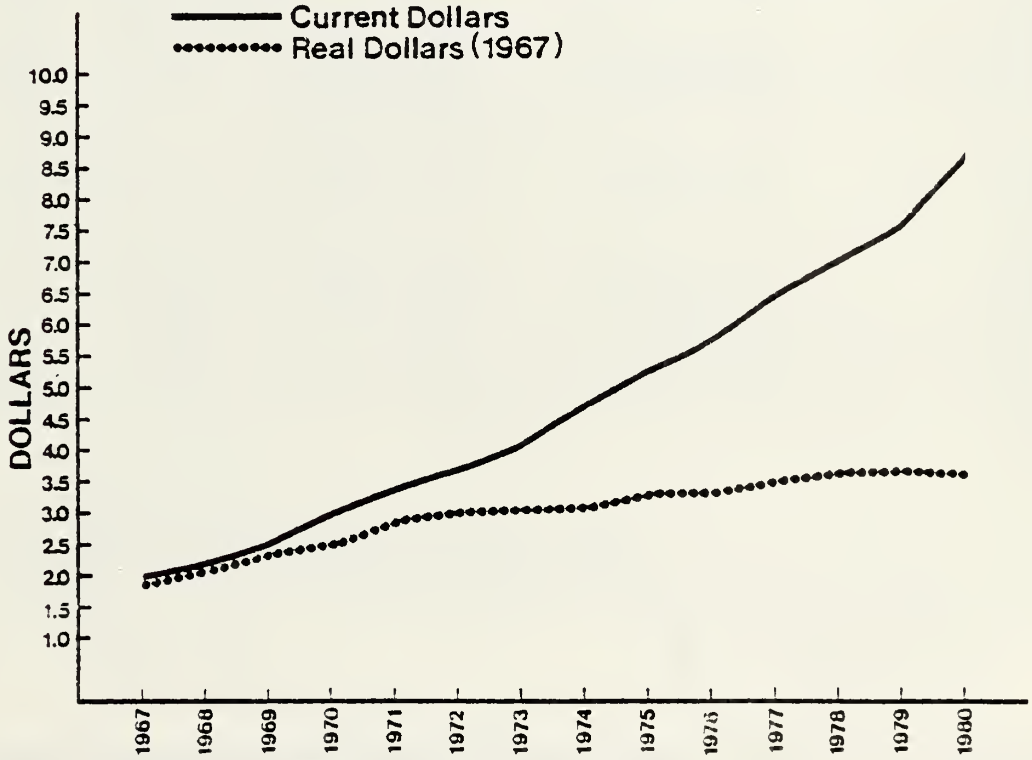
TABLE 2-10

TRENDS IN OPERATING EXPENSES (1967-1981)

COST AND FARES PER PASSENGER FOR MBTA OPERATIONS
1967 - 1980



COST PER MILE FOR MBTA OPERATIONS 1967 - 1980



TRENDS IN COSTS/PASSENGER AND COST/MILE ON THE MBTA

Figure
2-10

Year*	Operating Expenses** ($ Millions) Current Dollars	Operating Expenses** ($ Millions) Real Dollars	Revenue from Transportation*** ($ Millions)
1967	66.5(2)	68.6	43.3
1968	76.4(2)	76.2	48.3
1969	92.4(2)	84.5	63.3
1970	108.7(2)	93.3	60.7
1971	111.6(2)	90.0	53.2
1972	124.3(2)	97.6	53.7
1973	135.0(2)	99.0	52.2
1974	156.3(2)	104.7	51.5
1975	170.9(2)	103.6	51.3
1976	177.3(2)	101.2	53.1
1977	190.8	104.3	53.5
1978	201.6	104.4	55.2
1979	225.7(1)	104.3	56.7
1980	256.8	105.9	66.2
1981	262.4	98.4	81.8

(1) Unreimbursed Cost of Service - Cost of provided service for commuter rail was not included.

(2) Penn Central depreciation, amortization, and interest incomes were ignored.

*Expenses and revenues based on calendar or fiscal year, depending on MBTA budget format.

**Does not include private carrier subsidies.

***Does not include revenue from private carriers and other railway operations.

Source: MBTA 1981 Current Expense Budget and Auxiliary Data.

TABLE 2-11

MBTA EXPENSES AND REVENUE (1967-1981)*

Transit Authorities		Total Operating Expenses	Annual Vehicle/ Passenger Car Revenue Miles	Cost Per Vehicle Mile (in dollars)
NYCTA/MABSTOA	MB	449,817,500	85,509,000	5.26
	RR	836,179,260	232,903,970	3.59
Chicago	MB	195,493,450	81,017,500	2.41
	RR	100,980,740	48,862,800	2.07
So. Calif. RTD	MB	228,743,180	86,061,400	2.67
SEPTA	MB	79,467,991	33,642,690	2.36
	RR	38,304,083	13,719,540	2.79
	SC	34,284,446	5,824,910	5.89
	TB	4,202,125	1,510,219	2.78
WMATA	MB	142,360,430	42,928,955	3.32
	RR	51,710,941	16,816,448	3.07
MBTA*	MB	85,759,572	22,216,723	3.86
	RR	106,357,782	10,114,758	10.52
	SC	16,449,707	5,152,085	3.19
	TB	3,945,370	812,395	4.86
	CR	41,192,191	5,794,093	7.11
Trans. of NJ	MB	103,582,940	47,651,290	2.17
Greater Cleveland	MB	57,641,204	20,186,000	2.86
	RR	8,073,509	2,396,088	3.37
	DR	2,194,660	643,379	3.25
PAT Pittsburgh	MB	61,020,701	33,220,471	1.84
	SC	9,107,542	1,784,621	5.10
Baltimore	MB	45,784,253	22,545,147	2.03
	DR	511,918	253,000	2.02
Bi-State DA-St. Louis	MB	65,214,862	23,798,398	2.74

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*MBTA figures are for calendar year 1979.

Source: U. S. DOT, Transportation Systems Center, Section 15, "Annual Report," 1981.

Key:
MB - Motor Bus
SC - Street Car
DR - Demand Responsive
RR - Rapid Rail
TB - Trolley Bus
CR - Commuter Rail

OPERATING EXPENSES PER VEHICLE MILE (FISCAL YEAR ENDING BETWEEN 7/01/78 AND 6/30/79

TABLE 2-12

interest on unfunded debt). As a result, information presented in Table 2-12 may not provide a true comparison of operating costs. A more detailed comparison of MBTA costs with those of other transit properties has been conducted for the MBTA Management Practices Study.

2.6 SOURCES OF FUNDING

As already noted, only 21 percent of the funding for the MBTA is generated by passenger revenue. The remainder comes from the taxpayer, indirectly through the state (approximately 40 percent in 1980), the federal government (8 percent), and the local cities and towns (26 percent). The amounts received from each of the sources between 1971 and 1980 are shown in Table 2-13 and Figure 2-11.

Although funding from all levels of government increased in absolute terms, the relative percentage of MBTA costs carried by each source has increased for some governments and decreased for others (see Figure 2-12). The cities and towns in the MBTA district provided nearly 77 percent of the total taxpayer assistance in 1971; the state paid 22 percent in the same year.

The federal Section 5 operating assistance is scheduled to be phased out over the next three years. It is likely that increased farebox revenue would be put toward maintaining current service levels with reduced federal funding. Previously, an increase in revenue from fare increases would have affected the deficit and the amount paid by the local cities and towns in the MBTA district and by the state.

2.7 OPERATING FACTORS AND TRENDS

The category of operating factors and trends contains several different types of indicators which may be used to assess recent changes in the system. For example, this section discusses trends in energy efficiency and consumption in the MBTA system, trends in peak-load factors, and the trend in overall efficiency as measured by cost per passenger-mile. Also, this section provides information on the capacities of the MBTA system, both with and without the current constraints of vehicle fleet size and signal system capabilities.

2.7.1 Energy Use and Efficiency

The energy efficiency of the MBTA has been increasing over the last few years. From 1980 to 1981, energy efficiency increased by 2.4 percent (based on revenue miles), and energy consumption declined by 12 percent. As displayed in Table 2-14, energy efficiency (based on revenue miles) increased by 11.5 percent* from 1.0283 in 1978 to 1.1467 in 1981, and energy consumption is down by 15.7 percent in 1981.

The improvements in energy efficiency do include the closing of the South Boston Power Plant. Since energy use by the system is predominantly electric, the closing of the South Boston Power Plant produces a large impact on the energy savings. However, Table 2-14 indicates that use of automotive fuels has also declined significantly in addition to electric energy.

Two projects are now underway to reduce automotive energy use. The Authority has undertaken a program to evaluate the effectiveness of a diesel fuel additive in improving MPG. Manufacturer claims of 10 percent or greater fuel economy, if correct, will result in savings of over 600,000 gallons of diesel fuel per year.

The Authority has also awarded a contract to supply and install an automotive fuel management pilot system to automatically control and monitor gasoline dispensing. If the project is successful, the Authority will consider installing the management system at all locations to control gasoline and diesel fuel. Furthermore, the Authority is eliminating the use of No. 6 heating fuel at two major locations (Charlestown and Everett) and replacing the heating systems with more energy efficient boilers (dual gas/No. 2 oil boilers have been installed at Everett).

In the area of electric power, obsolete 25 HZ power conversion facilities are being replaced with energy efficient, lower energy cost substations to further reduce dependence on 25 HZ power purchased from Boston Edison Company through the inefficient frequency converter at South Boston.

The energy use reduction from 1980 to 1981 is 533,065 x 10^6 BTU, which is the energy equivalent of 4,240,738 gallons of gasoline. The dollar value of this energy saving is on the order of $3.4 million to $4.2 million depending on the price per gallon for the quantities of fuels saved (gasoline, diesel fuel, No. 6 oil, aviation jet fuel). This saving equals 20 percent to 26 percent of the increased operating income in 1981 compared with 1980 as shown in Table 2-14.

The fuel efficiency of MBTA revenue vehicles translated into revenue vehicle miles per gallon of gasoline is shown to have increased from 1.02 to 1.14 from 1978 to 1981 (Table 2-14). By comparison, the average commuter automobile produces 15 vehicle miles per gallon of gasoline.

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*Information on energy efficiency was provided by the MBTA Office of Energy Conservation.

Calendar Year	MBTA Operating Income	MBTA Non-Operating Income	Total Assessment Upon MBTA Cities & Towns	Total State Financial Assistance	Total Federal Financial Assistance	Payments Made By Outside Cities & Towns
1971	$54,333,806	$ 5,152,722	$ 63,139,222	$17,896,842	-	$ 256,909
1972	54,966,090	4,872,019	75,554,063	19,196,304	-	361,418
1973	53,661,255	6,170,996	55,762,086	54,924,845	-	409,193
1974	52,879,664	10,667,444	69,779,097	58,919,886	$ 6,241,114	822,191
1975	52,693,955	11,724,241	73,123,805	73,876,432	11,172,532	1,003,701
1976	55,079,065	3,913,317	77,422,791	78,342,795	16,868,565	1,051,897
1977	55,437,432	4,579,221	84,142,099	85,178,488	22,200,066	1,384,148
1978	57,299,566	8,099,828	80,548,972	98,652,010	26,628,398	1,861,462
1979	58,991,159	13,650,718	82,067,271	112,604,709	27,422,397	1,968,721
1980	68,847,531	13,622,874	92,441,452	140,074,970	29,328,419	3,385,982
1981**	79,885,400	11,573,076	106,049,166	135,097,629	30,750,000	5,870,000

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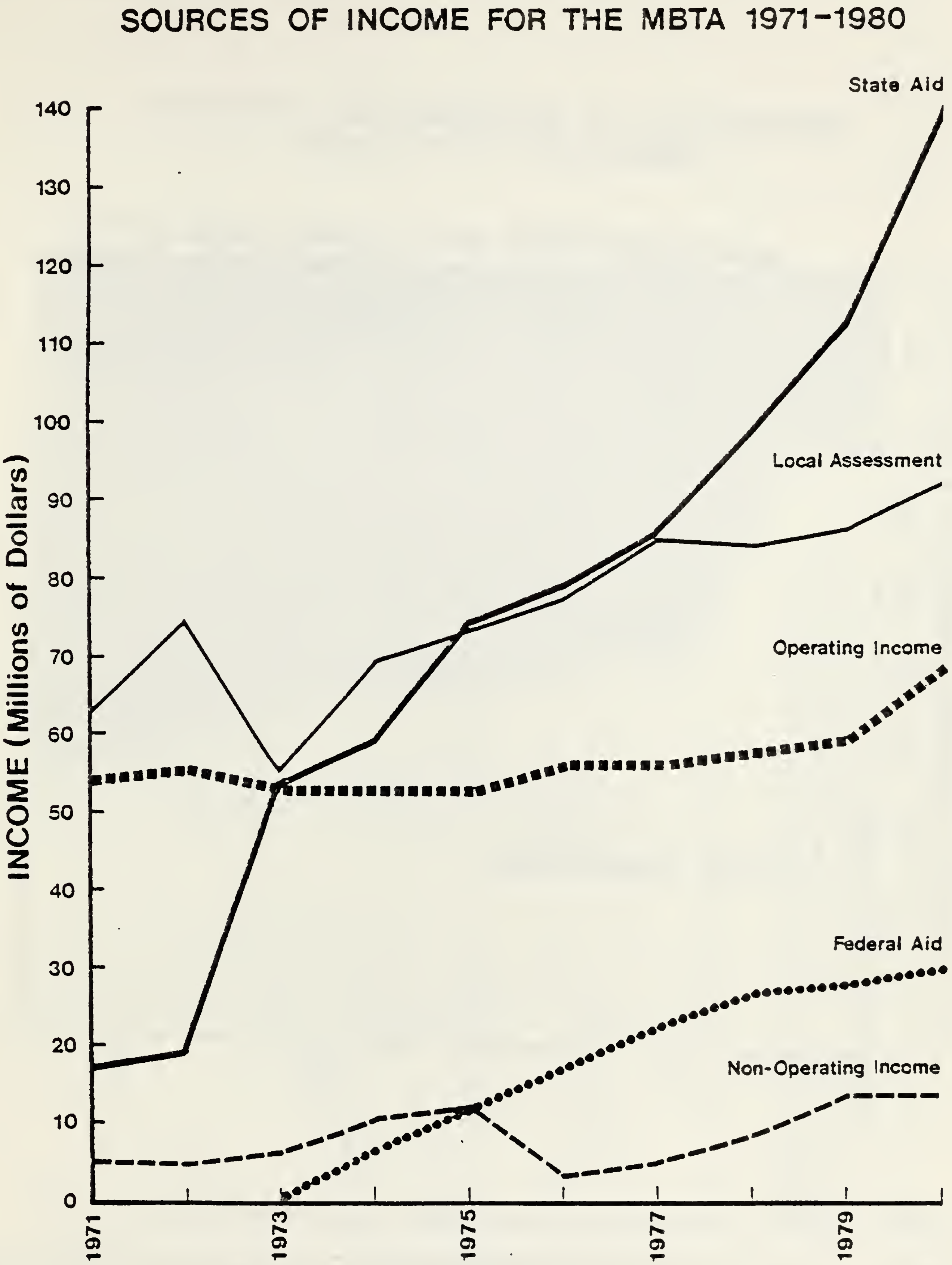
*All figures are rounded to the nearest dollar.

**Figures for 1981 are approximate.

Sources: 1981 Current Expense Budget and Ancillary Data, 1980 MBTA Annual Report.

MAJOR SOURCES OF MBTA INCOME (1971-1981)*

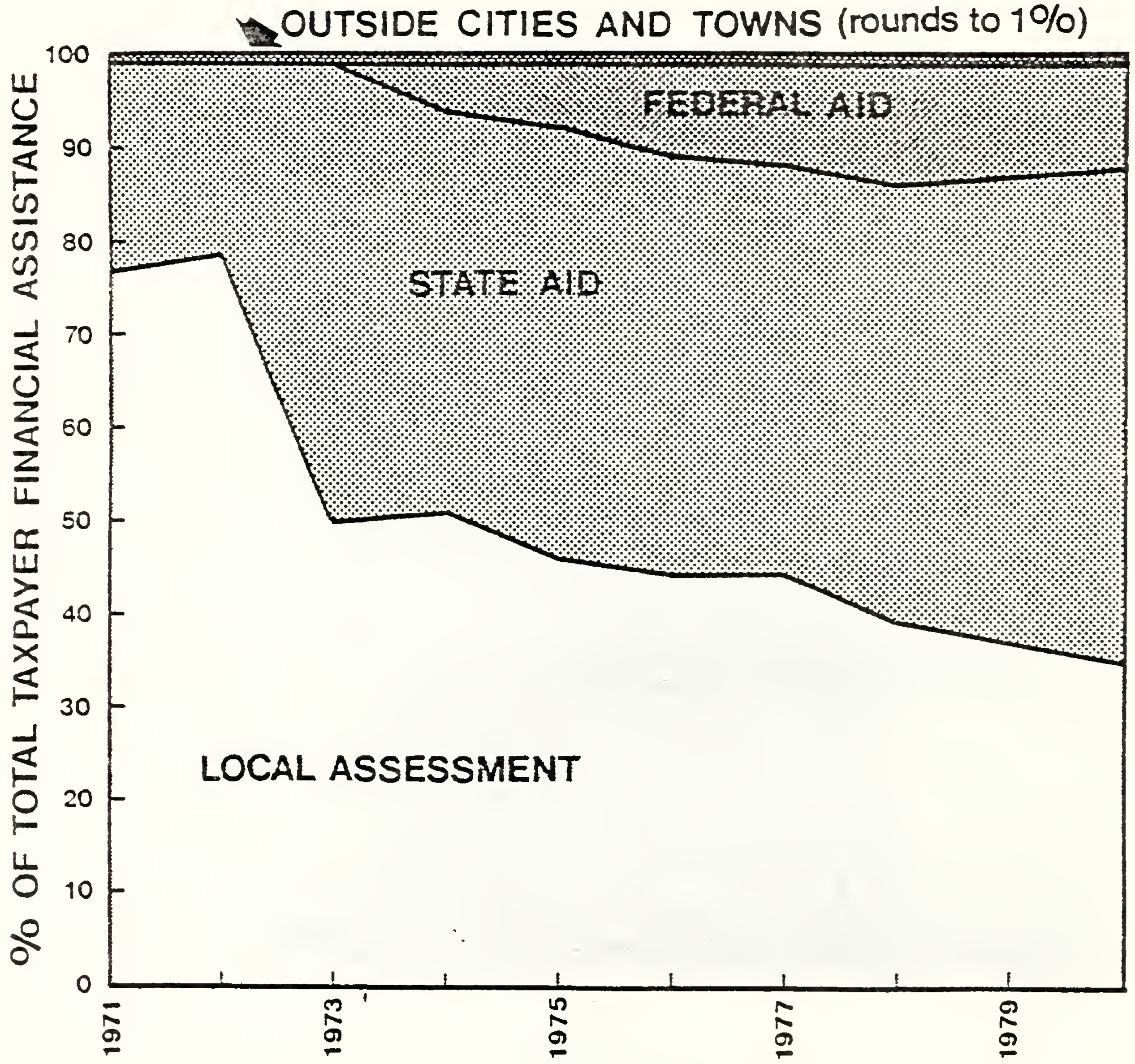
TABLE 2-13



Sources of Income for the MBTA (1971-1980)

Figure
2-11

DISTRIBUTION OF GOVERNMENTAL FINANCIAL
ASSISTANCE TO THE MBTA



Source: M.B.T.A. Office of Budgets and Operations Analysis

TRENDS IN GOVERNMENT FUNDING OF THE MBTA

Figure
2-12

Fuel*	1978	1979	1980	1981
No. 1 Diesel	975,376	973,550	971,310	921,679
Gasoline	60,487	59,466	55,417	48,643
Electric*	3,608,267	3,581,407	3,420,903	2,944,243
TOTAL	4,644,130	4,614,423	4,447,630	3,914,565
Fuel efficiency per revenue mile (miles/gallon equivalent)**	1.0283	1.0432	1.11956	1.14672
Fuel efficiency for total miles (miles/gallon equivalent)**	1.1185	1.1333	1.2192	1.2452
Revenue Miles	37,991,810	38,295,961	39,613,068	35,711,187
Rev. & Non-Rev. Miles (Total Miles)	41,325,273	41,604,191	43,139,771	38,778,065

Source: MBTA, Energy Conservation Office

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*Includes fuels used for transportation; electric use includes both transportation and non-transportation uses.

**Translates BTU's into equivalent gallons of gasoline (125,701 BTU's/gallon of gasoline).

TABLE
2-14

ENERGY USED BY THE MBTA - 1978-1981 (MILLION BTU'S)

The reasons for the relatively high energy use by MBTA vehicles compared with the average commuter automobile is caused by the unused capacity in transit vehicles, due to the predominant one-way flow of passengers in the AM and PM peaks and the concentration of ridership during these peak periods. Also, as noted previously, about 30 percent of the electric energy is used for wayside loads which are not directly related to moving vehicles. However, the more realistic measure of energy efficiency is in terms of passenger miles per gallon of fuel.

Using the 1981 figure of 4.29 passengers per revenue mile for the MBTA multiplied by the 35,711,187 revenue miles in 1981 (Table 2-14) produces 153,201,000 passengers. Assuming the average passenger trip length is 5 miles, the number of passenger miles becomes 766,005,000. Dividing the passenger miles by the fuel equivalent of 31,141,876 gallons of gasoline produces 25 passenger miles per gallon of fuel equivalent.

Assuming the average commuter automobile carries 1.4 persons, the energy efficiency becomes 21 passenger miles per gallon of fuel. This indicates that the energy efficiency of the MBTA transportation system is about 1.2 times the energy efficiency of the average commuter automobile. It should be noted that all of the MBTA gasoline and a portion of the diesel fuel are used in non-revenue vehicles. Therefore, this energy is not directly involved in moving revenue passenger vehicles. If the comparison of the energy efficiency of the MBTA and private cars were made during the peak periods and only the energy used to move the vehicles considered, the energy efficiency of the MBTA would be considerably greater.

In 1980, the Authority purchased 7,069,211 gallons of diesel fuel for buses and non-revenue vehicles. Assuming 296,200,000 passenger miles for buses, the energy efficiency is greater than 42 passenger miles/gallon since a portion of the diesel fuel is used in trucks.

What becomes evident here is that a large amount of energy investment made in the system as a whole results in high energy use per passenger mile when the system is being used at low capacity. However, there is a low marginal cost associated with the addition of increased ridership. For example, if the Authority increased revenue mileage by 10 percent to handle a 10 percent increase in ridership, the energy efficiency would be 4.4 percent greater than the total figure shown for 1981 since a large portion of the electric energy used by the system is fixed. In 1981, 29 percent of the total electric energy used by the system was consumed by non-traction loads, and this portion of the electric use would be unaffected by increased train mileage. Appendix F provides a sample calculation to show the effects of such a mileage increase on system energy efficiency.

2.7.2 Peak Load Factor Standards and Existing Conditions

In viewing energy efficiency factors and the quality of service provided by the system, an analysis of existing load factors on various routes is essential to determine both operating trends and short-term service planning. In 1977, as part of the Service Policy for Surface Transportation established by the MBTA, peak-load factor standards were created. These standards demonstrate a relationship between passengers per vehicle and seating capacity for time and type of service provision. The maximum load standards for surface travel are as follows:

Maximum Load Standards - Bus and Trackless Trolley Service*

Service Function	Peak 30 Minutes**	Total Peak Period	Midday	Evening
Linehaul	100%	100%	100%	100%
Feeder	140%	120%	100%	100%
Cross-Town	140%	120%	100%	100%
Inter-Town	140%	120%	100%	100%

Maximum load factor standards have not been defined in this manner for the rapid transit lines.

The existing load factors observed on the surface routes range from relatively low values (less than .50) on some suburban service at off-peak times to well over 3.0 on the rapid transit and trolley cars during the peak. The load factors by route for peak hours are provided in Appendix C-2. A notation has been made for each route where the load factor has increased since last year. The average peak period load factor for all bus routes combined was .99 in 1981, which compares with a slightly lower level of .97 in 1980.

2.7.3 Operating Capacities

Whereas load factors relate only to seating capacity on individual vehicles, the operating capacity of a system is estimated as a function of both the seating and standing capacity on vehicles (both surface and rapid transit) and the number of vehicles making runs. The effective operating capacity is less than the absolute operating capacity because of such factors as passenger flow, train flow, and spatial distribution of passengers on trains and in stations. For the MBTA rapid transit system, the signal system has also provided a design constraint.

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*MBTA, Service Policy for Surface Public Transportation, August 3, 1977.

**During 1981, the MBTA's standard was temporarily changed to 160 percent for all bus routes (during peak 30 minutes) as a budget reduction measure.

The theoretical operating capacity of the surface system is much less constrained by the current infrastructure and is principally determined by the number of assignable vehicles (1,025 buses and 50 trackless trolleys in 1981), the number of scheduled trips (7,121 daily in 1981), and the number of drivers available.

To estimate the current and potential theoretical operating capacity for the rapid transit system is more complex. Detailed in Appendix C-3 is a line-by-line description of this process for normal and crush loads under four different conditions:

1. Actual Capacity. Reflects the estimated line capacity given present service schedules.

2. Constrained Capacity. The number of passengers accommodated with the maximum amount of service which can be provided given the existing vehicle fleet.

3. Potential Capacity. The number of people that can be carried with an unlimited fleet and station modifications necessary to accommodate longer trains.

4. Design Capacity. The maximum capacity possible given the design limitations of the signal system and assuming absolute schedule adherence.

Table 2-15 provides a summary of this information for the rapid transit lines. A detailed explanation of the process and assumptions used to derive this information may be found in Appendix C-3, Operating Capacity.

	RED	BLUE	ORANGE	GREEN*O
Current Estimated Peak Hour Volume	15,000	6,000	7,000	7,000
Active Fleet (# of vehicles)	164	70	120	196
Constraint (85% of Active Fleet)	140	60	102	168
Actual Capacity of Existing Operation (in passengers)				
Normal	12,716	5,091	7,173	6,221
Crush	16,592	6,432	9,117	7,972
Potential Capacity with Maximum Utilization of Existing Fleet				
Normal	16,157	7,480	10,013	11,562
Crush	21,082	9,452	10,760	14,300

*OHybrid vehicle was developed for purposes of calculation with a 2-car PCC/1-car LRV.

TABLE 2-15

CURRENT AND POTENTIAL OPERATING CAPACITIES WITH CURRENT INFRASTRUCTURE

3.0 RIDERSHIP IMPACTS OF RECENT FARE INCREASES

In response to the rising cost of operating the MBTA and restrictions on the funding levels, the Massachusetts Bay Transportation Authority increased fares and reduced service in recent years. These changes have already been described in Section 2.0 of this report. Actions of this nature have had a negative effect on ridership levels, causing passengers to seek other less costly or more convenient alternative transportation. The rider's response to changes in fares or service levels, quantified in terms of elasticities, depends on several factors including: the proportional change in the fare or service level; the trip characteristics such as sub-mode used (bus or rapid transit), time of travel or trip purpose; and the socioeconomic characteristics of the rider such as age or income and the cost characteristics of alternative modes.

This section presents a brief review of the literature on fare and service elasticities. The estimated ridership changes on the MBTA due to the recent fare increases are then presented. An elasticity analysis has been performed to estimate these changes, and an assessment of the usefulness of and problems with elasticity analysis is made.

3.1 ELASTICITY ANALYSIS AND RIDERSHIP RESPONSE

The ridership response to a change in either fare or service level may be quantified as an elasticity. Generally, elasticity analysis in economics is a measure of the responsiveness of consumers to changes in the price (fare) or the quality of a good (service). Here we are examining fare elasticity which is a static measure of the proportional change in a dependent variable (ridership) with a percentage change in price. Since the elasticity is found by computing the ratio of two percentages, it is a dimensionless number, meaning that its value does not depend on the units used for measuring demand and price.

For example, in this case, we are interested in discovering the price level at which riders will cease to use transit or will find alternative modes of transportation to be more attractive than using the transit service provided at a given cost. To do this, looking at the historic percentage change in ridership with each percentage change in fare or service may be useful. To quantify changes in levels of service in terms of the perceived value to riders is difficult. However, they may be derived by substituting a measurable value such as change in headway or frequency, etc.

Although there are several methods for calculating elasticities, the empirical elasticities referred to throughout this study are arc elasticities. An arc elasticity is defined as a percentage change in ridership based on a percentage change in price relative to the average of the before and after ridership and price values, respectively. It is defined mathematically as:

$$e_{arc} = \frac{(\ (q^2 - q^1)/(\ (q^2 + q^1)/2)\ )}{(\ (p^2 - p^1)/(\ (p^2 + 1q)/2)\ )}$$

where q^1 = ridership before fare increase

where q^2 = ridership after fare increase

where p^1 = fare before fare increase

where p^2 = fare after fare increase

Thus, an arc elasticity is the ratio of the fractional change in actual demand (ridership, in this case) to a fractional change in price (the fare) here.

Service elasticities are derived in the same manner by substituting a measurable value for the change in the level of service, such as headway (service frequency) change.

For example, a review of the literature on fare changes in other cities has pointed to a range of elasticities that could be applied to Boston. Although this will be demonstrated in greater detail in Section 3.2.4, these are the ranges into which transit fare elasticities fall.

Peak Period

rapid transit = -.08 to -.36
local bus = -.17 to -.38
express bus = -.03 to -.33

Off-Peak Period

rapid transit = -.18 to -.44
local bus = -.26 to -.41

In general, the lower estimates are based on elasticities derived from Boston's past fare increases. For a review of elasticities, the reader is directed to two basic DOT publications.*

3.1.1 Review of Past Rider Response

Ridership response to changes in the transit fares and service levels has been studied extensively over the past 20 years. Difficulty arises, however, in trying to isolate the effects of just a fare increase or service change. A fare increase is typically coupled with a change in service, marketing technique or promotional campaign, making it difficult to determine the sole effects of a fare change. Other exogenous factors, such as a gasoline price increase or supply shortage, might obscure the effects of a fare or service change. Despite these problems, several basic conclusions have been drawn from previous experience. They are summarized below.

3.1.2 Fare Changes and Elasticity

- A general rule--the Curtin Rule-- that has been used by the transit industry in the past, states that for every one percent increase in fare, there will be a corresponding decrease of one-third of one percent in ridership. Although actual ridership response depends upon the particular city and circumstances surrounding the fare change, the use of this factor is still adequate for general systemwide estimates.

- Transit demand is inelastic with respect to fare; that is, a change in fares will cause a lower proportional change in ridership.

- Elasticities to bus fare changes are generally higher than rapid transit elasticities.

- Off-peak elasticities are generally higher than peak period elasticities. This corresponds with the responses of riders making work trips being less sensitive to fare changes than those making shopping trips.

- Empirical evidence does not generally support the theory that the relative response to a fare change depends upon both the absolute and proportional magnitude of the change. The elasticities derived using a relatively low base fare and a relatively minor increase should be transferable to other situations. Until recently, however, most fare increases have not typically been drastic, making it difficult to generalize as to the exact impacts of the 1980 and 1981 changes.

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*U.S. DOT, FHWA, Traveler Response to Transportation Systems Changes, 1981; U.S. DOT, UMTA, Patronage Impacts of Changes in Transit Fares and Service, prepared by Ecosometrics, Inc., 1981.

3.1.3 Service Changes and Elasticity

- Transit demand is inelastic with respect to changes in service, that is, a one percent change in a service characteristic (e.g., service frequency, vehicle miles) will produce a lower percentage change in ridership.

- Off-peak and weekend service elasticities are higher than peak period service elasticities.

- Ridership levels are more responsive to service changes on routes with lower levels of service than those with higher levels of service; for example, a reduction in service on a route with high headways (low bus frequency) would produce a greater loss in riders than a similar reduction on a route with low headways (high frequency).

- In general, ridership is less responsive to fare changes than to an equivalent percentage change in service, i.e., fare elasticities are lower than service elasticities.

- The impacts of service changes have most typically been measured in terms of the change in headways or vehicle miles of travel.

- Headway and vehicle-mile elasticities are similar, based on actual case studies. Aggregate vehicle-mile elasticities are considered irrespective of whether they relate to frequency, route length, route density or service-hour changes.

- Ridership is more responsive to improvements in headway than in-vehicle time. This conclusion is drawn from the results of bus priority lane demonstrations in several cities (including Boston).

3.1.4 The Results of Fare Increases in Other Cities

In a further attempt to summarize the general effects of a fare increase, a review of the effects of fare increases in other cities has been conducted. This review reaffirms the conclusions of Curtin (1968) that response to fare increase is generally inelastic, i.e., ridership change is proportionally smaller than the fare change. The following is a description of case studies of fare increases and their impacts on ridership in other cities.

New York State Metropolitan Transportation Authority (MTA)

An EIS prepared in May 1981 predicted a loss of ridership for proposed fare increases of 15 and 40 cents on subway and bus lines and 20 and 50 percent increases on commuter rail lines. The amount of fare increase, projected loss in ridership, and revenues are shown as follows.

Ridership and Revenue

Fare Increase	Ridership	Revenue
subway and bus 15¢ commuter rail 20¢	-5.0% to -6.7%	+16.6% to 18.3%
subway and bus 40¢ commuter rail 50¢	-13.4% to -17.8%	+37.6% to 43.5%

The report analyzed subsequent effects on vehicular transportation, air quality, economic activity, lower-income groups and related areas.

Transportation

Fare Increase	Increase in Daily VMT-Regionwide
subway and bus 15¢ commuter rail 20¢	+0.3% to 0.4%
subway and bus 40¢ commuter rail 50¢	+0.8% to 1.1%

Air Quality

Fare Increase	Auto Emissions - Regionwide	
subway and bus 15¢	hydrocarbons	+0.3%
commuter rail 20¢	carbon monoxide	+0.7% to 1.0%
	nitrogen oxide	+0.2% to 0.4%
subway and bus 40¢	hydrocarbons	+0.7% to 1.0%
commuter rail 50¢	carbon monoxide	+0.8% to 1.1%
	nitrogen oxide	+0.8% to 1.0%

The EIS concludes "the projected range of increased emissions for either HC or CO does not represent a significant impact to regional air quality." The EIS stated that the fare increase would have little impact on the overall level of regional economic activity, but conceded there would be a greater impact on lower-income groups. For example, an individual earning $10,000 annually would have to spend an additional 1 percent of his income if the fare were raised 15 cents. (An individual earning $20,000 would pay an additional 0.52 of his income). Negligible impacts were reported on noise levels, water quality, land use, and cultural resources.

Data from a 1980 fare increase were also included in the EIS. Fares on all lines were increased an average of 20 percent, with weekend half-fare and senior citizens half-fare programs reduced, along with service quality reductions. This caused a 5.7 percent decline in subway ridership during the last six months of 1980, and 9 percent and 11 percent declines in ridership reported for two bus lines. Other lines, including Conrail and the Long Island Railroad reported ridership increases of 3 to 4 percent.

A different study reported ridership reaction to the 1966 New York City subway fare increase in the following way:

Period of Day	Ridership Decrease
7 AM - 10 AM	2.4%
10 AM - 4 PM	8.0%
4 PM - 7 PM	5.0%
7 PM - 11 PM	14.6%
11 PM - 7 AM	3.7%

As is apparent from the chart, work trips showed the smallest ridership decrease, with more significant drops in off-peak hours when more discretionary trips are likely.

Ontario Cities Study

Following a series of fare increass in 24 Ontario cities from 1975 to 1977, a study revealed changes in ridership ranging from an increase of 14.7 percent to a decrease of 35 percent. The average ridership decrease was 1.1 percent. The average fare increase was 26 percent and different market segments, i.e., children, students, adults were subject to different levels of increase. Based on a six-month period following the fare increase, average revenues for transit systems rose 18.5 percent.

Other salient points of this example include:

- Only one of the cities experienced a revenue loss from increasing its fares.
- "The effectiveness of a fare increase in producing increased revenue decreases with the time elapsed since the increase. It appears that transit riders need some time after the fare increase before they can switch to other transportation modes or eliminate certain unessential trips or both."

An earlier Ontario study of 14 cities in 1976 examined ridership levels within three months of fare increases. For large cities over 200,000, the shrinkage ratio was about -.20; i.e., a 10 percent increase in fares resulted in a 2 percent reduction in ridership. For smaller cities, the shrinkage ratio was about -.33, or the same figure Curtin (1968) reached.

North Virginia Bus Routes

The effect of peak period fare increases on a series of bus lines running from Northern Virginia to Washington D.C., was reported in 1978. Trip distances varied from 5 to 16 miles, and patronage was seasonally adjusted.

Along a 5-mile route from Arlington to Washington, D.C., the fare was increased 52 percent. Subsequent ridership loss was 6.92 percent (elasticity - 28 percent). On the Falls Church to Washington line, a fare increase of 31 percent resulted in a ridership drop of 8.4 percent (elasticity - .27 percent). Along the 16-mile Shirley Highway Corridor, a 40 percent fare increase showed a 1.05 percent decrease.

The report observes that the longer Shirley Highway Bus route showed less elasticity with respect to transit patronage. The premium express service offered by the line appears less sensitive to price increase. A fourth bus line reported an increase in passenger ridership following an increase in fares. The report claims unidentified phenomena are responsible for this occurance.

The conclusion:

> There was little evidence of passengers on either service shifting travel outside the peak periods to avoid higher fares. The fare increase had no effect on auto travel. These results suggest applying different pricing policies to different types of transit service.

California Fare Increases

A report published in 1980 showed effects on ridership and revenue of fare increases in Los Angeles, San Diego, and the San Francisco-Oakland area.

The Southern California Rapid Transit District (SCRTD) carried 330 million riders in 1979 on 220 routes. Its basic fare was 40 cents, 20 cents additional for express, 10 cents additional for transfer, and 10 cents for seniors. In the spring of 1980, a fare increase raised the base fare to 50 cents, with "significant" increases in the cost of passes, and a 10 cent/ stage increase on express lines. Ridership declined 6.7 percent, and revenue increased 22.1 percent.

The San Diego Transit Corporation (SDTC) carried in 1975 120,000 riders weekly. In August of 1978, its base fare was 40 cents, with 20 cents for seniors and 25 cents for youths. The fare increase raised the basic fare to 60 cents, off-peak senior to 30 cents, and express to 75 cents. As a result, ridership declined 20 percent, and revenues increased 41.6 percent.

AC Transit services Alameda and Contra Costa counties with trans-bay service from Oakland to San Francisco. On the average day, it carries 247,000 passengers. In 1978, its basic fare was increased from 35 cents to 50 cents, with "moderate" increases for trans-bay and express service, previously set at $1.25. Under the fare increase, ridership declined 9.8 percent, and revenue increased 43 percent.

Patronage, clearly, was more inelastic in Southern California and the Bay area than it was in San Diego. The report concluded that short-trip users were paying more, generally, in each California city studies and that staged or distance-based fares would be more equitable:

> Highly differentiated scenarios offer the greatest balance for modest patronage losses combined with significant revenues.

Baltimore

Zone fares were raised in Baltimore in March of 1976. Regular fares were increased from 30 to 35 cents (off peak) and 40 cents (peak hours) in addition to 10 cents/zone. Revenue increased an unspecified amount, while adult ridership declined. After a year's observation, the study revealed an elasticity level one-half of the accepted norm of Curtin (.33), or .165.

In conclusion, the studies observed have shown ridership to decline roughly one-third of one percent for every percent increase in fares. Few of the studies available have gone beyond observations of ridership declines. The New York State Metropolitan Transportation Authority's is the only report observed to include calculations for increases in VMT and subsequent air quality impacts. The EIS concludes that impact is minimal. The New York State EIR also is the only observed study that examines socioeconomic data to determine possible imapcts on lower- and moderate-income groups.

3.2 RIDERSHIP CHANGE FROM 1981 MBTA FARE INCREASE

A comparison of November 1981 and November 1980 ridership levels indicates that approximately 90,200 fewer trips were made on an average weekday in November 1981.* This translates into a loss of roughly 15.0 percent of the average weekday trips made on the MBTA. Of the 90,200 trips, it is expected that approximately 56,700 fewer trips (9.4 percent) were made because of the fare increase of August 1981. Service cuts accounted for a loss of 32,000 trips (5.3 percent) on an average weekday. In addition, it has been estimated that 1,500 of the trips (0.2 percent) were lost because of the bus replacement program in effect during track repairs on the Dorchester Branch of the Red Line. Other trips might have been lost due to deterioration of levels of service on the rapid transit lines. The ridership levels for an average weekday in November 1980 and November 1981 are shown by mode in Table 3-1. The ridership profile is also displayed.

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*The difficulty and uncertainty in estimating ridership on the MBTA is addressed in Appendix B.

The most significant changes in the types of riders were the increase in the number of elderly riders due most probably to the free off-peak fare, the increase in the number of pass users, and the decrease in the number of riders who pay the full adult cash fare. The smallest impact was on riders who use only rapid transit. The greatest loss was in the number of trips made using both rapid transit and bus for a single trip. A more detailed review of the procedure and results is provided in Appendix E.

Another way of presenting these changes is to illustrate the change in unlinked trips. This eliminates the uncertainty associated with linking trips; however, the number of unlinked trips is less meaningful because it is not directly related to a person-trip. That is, one linked trip made by transferring from a surface vehicle to a rapid transit line would be counted as two unlinked trips, one on surface and one on rapid transit. A single bus trip would be counted as one unlinked bus trip; a single linked trip where a transfer is made from one bus to another bus would be counted as two unlinked surface trips. The purpose of displaying the change in unlinked trips is to facilitate the derivation of fare elasticities and to isolate the effects of service changes. The percentage change in unlinked trips is very similar to that observed in linked trips:

	Nov. 1981	Nov. 1980	Percent Change
unlinked rapid transit	310,100	360,300	-13.9%
unlinked surface	422,100	507,000	-16.7%
TOTAL	732,100	867,300	-15.6%

3.3 ANALYSIS OF RIDERSHIP LOSS

Elasticities can be calculated from the change in ridership and fare levels using November 1980 and November 1981 levels to represent before and after conditions, respectively. The elasticities implied in the data for unlinked trips are as follows:

	# Trips(%) November 1981	# Trips(%) November 1980	Change(%)
rapid transit only	137,997(27.0%)	156,300(26.0%)	- 18,303(-11.7%)
combined rapid transit & surface	194,218(38.0%)	234,500(39.0%)	- 40,282(-17.2%)
surface only	178,885(35.0%)	210,500(35.0%)	- 31,615(-15.0%)
TOTAL	511,100(100.0%)	601,300(100.0%)	- 90,200(-15.0%)
adult - full cash	209,551(41.0%)	321,100(53.4%)	-111,549(-34.7%)
- pass	174,796(34.2%)	151,500(25.2%)	+ 23,296(+15.4%)
elderly & handicapped	62,865(12.3%)	46,300(7.7%)	+ 16,565(+35.8%)
student & children	44,977(8.8%)	59,500(9.9%)	- 14,523(-24.4%)
other free	18,911(3.7%)	22,900(3.8%)	- 3,989(-17.4%)
TOTAL	511,100(100.0%)	601,300(100.0%)	- 90,200(-15.0%)

Summary of Ridership Loss for Average Weekday in November

Table 3-1

	e arc*
unlinked surface	-.32
unlinked rapid transit	-.48
TOTAL system unlinked	-.38

---

*Uses ridership values as reported above; fare levels used were as follows:

	Nov. 1980	Nov. 1981
unlinked surface	21.8 cents	39.6 cents
unlinked rapid transit	42.4 cents	60.0 cents
linked total	43.5 cents	69.7 cents

These elasticities include the effects of both a fare increase and service reduction and, therefore, tend to be higher than those expected solely from a fare increase. An attempt was made to isolate the effects of the service reduction from the fare increase. The number of trips lost due to the service cuts was estimated using the percent reduction in service and a derived service elasticity.

The fare elasticities developed by adjusting for service reductions are presented below:

- unlinked bus trips: e arc = -.19

  assuming a 12.0 percent reduction in bus service resulted in a 7.3 percent drop in ridership;

- unlinked rapid transit trips: e arc = -.41

  assuming a .2 percent drop in riders due to the replacement bus service on the Red Line and a loss in the rapid transit portion of a combination trip because of the bus service cuts:

- total unlinked trips: e arc = -.27

The elasticities for buses appear to be more in agreement with the literature after adjusting for service changes. However, the rapid transit elasticities are still significantly higher than expected. This implies that other forces such as service reliability might have been acting to discourage ridership during this time.

The ridership response to changes in the reliability of service is hard to quantify. The MBTA measures the number of trips missed on a daily basis. The MBTA has set a performance level to meet 98 percent of all schedule trips. The increase in the number of missed trips over the last few years was used as a measure of reliability. Assuming that trips missed consistently would produce the same effects on ridership as service cuts, the change in the number of missed trips since the end of 1979 was applied to a service reduction elasticity to further adjust the fare elasticity on rapid transit. This procedure produced the following:

- unlinked rapid transit trips: e arc = -.36

  This is still somewhat higher than expected from previous experience. More reasonable estimates were obtained by using the composite effect of the 1980 and 1981 fare increases. The elasticity derived using pre-1980 fare increase levels are as follows:

- unlinked rapid transit trips: e arc = -.24

  Adjusting this for service changes would produce an arc elasticity of -.22. It appears that the combined effects of both fare increases on the rapid transit lines would explain the unexpectedly high ridership loss that resulted.

3.4 USEFULNESS OF ELASTICITY ANALYSIS

As can be deduced from the analysis just presented, a wide range of elasticities can be used to project the impacts of service or fare changes on ridership levels. Professional judgement must be applied to select the appropriate elasticities to evaluate a particular situation. In general, this type of projection is necessary to develop reasonable estimates for the revenue and ridership consequences of implementing a set of measures. It supplies a transportation provider with a quick and inexpensive analysis technique. For the purposes of comparing alternative strategies, elasticities are expected to be even more useful tools as it can be assumed that any bias present would be the same for each alternative.

4.0 ENVIRONMENTAL IMPACTS

The most significant environmental impacts that can result from a fare increase on the MBTA relate to changes in air quality and energy consumption. As the cost of public transportation increases and travelers stop using transit, they must either take some other mode of transportation for that trip or not make that trip. If passengers switch to either private automobiles or taxis, the total number of vehicle miles traveled (VMT) will increase, causing emissions and energy consumption to rise.

The magnitude of the air quality impacts can be estimated using an analysis method that considers three types of changes:

1. The change in the total regional VMT.

2. The change in congestion (queue length) on major Boston radial highways.

3. The change in traffic volumes at selected intersections designated as CO (carbon monoxide) Hot Spots in Boston.

The change in total regional VMT is of interest in order to ascertain potential impacts on the production of photochemical oxidants, a major component of smog. In general, as VMT increases, emissions of non-methane organic compounds (NMOC) and nitrogen oxides (NO_x) increase as well. Some of these compounds, particularly hydrocarbons (HC) and nitrogen oxides (NO_x), act in the presence of sunlight to produce photochemical oxidants.

As automobile use increases, congestion on facilities that are already crowded might worsen, causing increased queues, decreased speeds and, therefore, increased delays for all automobiles on that facility. This, in turn, leads to a greater increase in CO and HC emissions than would be anticipated based on VMT changes alone, because CO and HC pollutant emission levels increase as vehicle speeds decrease.

Congested conditions at major intersections might also be exacerbated by increased traffic volumes from diverted transit users. This also would lead to increased CO concentrations. CO, unlike HC, is a localized problem related to traffic at a specific location. Intersections where existing conditions have already created CO problems would be the locations most likely to be sensitive to CO increases that result from increased traffic volumes.

In order to estimate the magnitude of air quality impacts for this study, a determination of the increased automobile use resulting from the fare increase was made. This is described in the next section. Following that description, the air quality impacts will be estimated and analyzed. The relation to the state's air quality implementation plan (SIP) will be discussed. The energy and noise impacts will also be addressed.

4.1 ANALYSIS OF DIVERSIONS

The combined ridership loss due to the two fare increases of July 1, 1980, and August 1, 1981, was used to estimate the diversion to other modes and, hence, the air quality and energy impacts. It is estimated that a net decrease in daily passenger trips of 85,000 resulted since the end of 1979, due primarily to the fare increases over this time. Of these, between 55 and 65 percent of the diversions (46,750 to 55,250 trips) resulted from the 1981 MBTA fare increase. The 85,000 figure represents 42,500 round trips, of which 24,000 (57 percent) are peak trips and 18,500 (43 percent) are off-peak trips.*

The lost trips were divided into those made within downtown Boston, those within the core, excluding the downtown, and those core-bound trips originating outside the core from each of the six CTPS travel corridors. The core was defined as Boston and most of its immediately adjacent towns. Within each geographic category, the diverted transit trips were then assigned to alternative modes or trip-making behaviors. The alternatives were: taxi, automobile, commuter rail, private bus, walk/bike, other destination, and no trip. The percent of the travel in each category assigned to each mode is based largely on the relative accessibility of the alternative modes. Trip purposes, average trip lengths, automobile ownership, and other factors were also considered. Trips made by automobile or taxi were included in the estimate of increased VMT. Trips made to other destinations were expected to be made by automobile. A detailed description of the method and findings is provided in Appendix F-1.

4.2 AIR QUALITY IMPACTS

The Clean Air Act Amendments passed by the U. S. Congress in August of 1977 established health- and welfare-related standards for achieving air quality. These standards were established with two levels of attainment: primary standards (protecting human health) and secondary standards (those that prevent damage to property, materials, and vegetation). The State Implementation Plan outlines the steps that the state will take over the next five years to attain these federal air quality standards. Inventories of current conditions and forecasts of future emissions provide information for targeting the amount of emission reductions needed.

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*Although off-peak trips are generally more sensitive to fare changes, fewer off-peak trips were lost in this analysis, due to an off-setting increase in the number of off-peak trips made by the elderly. The proportion of total peak/off-peak ridership was considered in calculating the total of lost trips.

For the purposes of this report, these primary and secondary standards and areawide emissions levels were used as indicators of air quality impacts. Total predicted emission increases were compared to the standards for HC, CO, and NO_x. For lead, the fourth pollutant estimated, standards have not yet been established.

The possible health impacts of these pollutants were not analyzed separately but rather the established standards were considered to be adequate indicators of health impacts.

4.2.1 Regional VMT

Based on the estimated number of diverted trips, the choice of alternative transportation mode, the trip lengths, and the number of passengers per vehicle, the following increases in daily VMT are estimated:

• North Shore	18,800
• North	30,900
• Northwest	27,600
• West	30,900
• Southwest	25,400
• South Shore	51,800
• Within Downtown	9,600
• Within Core	35,100
TOTAL	230,100

The net result is, thus, an additional 230,100 daily VMT or approximately 70.6 million VMT annually. This represents an increase of roughly 0.5 percent of regional daily VMT.

The air quality impacts associated with the VMT changes reported above were estimated using EPA emission factors from their MOBILE2 program. The factors were selected based on the vehicle operating characteristics such as speed and operating mode temperature (cold/hot starts, hot stabilized), the characteristics of the Massachusetts vehicle fleet, and ambient temperatures. The basis for selecting these variables is described in Appendix F-6.

It is estimated that regional emissions associated with increased VMT increased by the following amounts due to the two recent fare increases.

• Non-Methane HC (NMOC)	191.3 tons/year
• Exhaust CO	2,929.2 tons/year
• Exhaust NO_x	242.6 tons/year
• Lead	4.7 tons/year

4.2.2 Air Quality Impacts - Highway Congestion

Additional highway congestion in the form of longer queues will occur due to higher traffic volumes. The greatest impact will be felt on the radial highways carrying commuters into Boston. These highways already carry significant traffic volumes and by adding traffic to these facilities, the queues will increase.

Increased queue lengths from the two recent fare increases have been estimated for morning and evening peak trips to and from Boston, respectively. The analysis uses an expressway queueing model, developed by CTPS, that predicts queueing delays based on daily traffic volumes relative to capacities at bottleneck points. The method is explained in Appendix F-3.

The additional automobile trips to Boston, identified in the diversion analysis, have been allocated to specific highways into Boston. These are identified in Table 4-1, for the AM and PM peak periods, along with the estimated increase in queue length. The changes in queue lengths range from just under 40 feet at the Sumner Tunnel during the morning peak period to almost 2,300 feet on the Southeast Expressway and Storrow Drive during the evening peak.

The larger changes in queue lengths are not due to extraordinary traffic changes, but rather due to the fact that these facilities do not have explicit queues. Since their base case queue speeds are faster, it takes a greater distance to generate a given amount of delay increase. It is expected that in actuality a queue of almost one-half mile would cause traffic to divert to alternate routes, such as Memorial Drive. It is likely that queues would not extend for more than one-quarter mile on either Storrow Drive or the Southeast Expressway. Larger queue estimates are shown to exhibit worst-case conditions.

The increased queues are experienced by all vehicles on these expressways during the morning and evening peak periods. Using EPA's MOBILE2 emission factors for automobiles, queue speeds reported in Table 4-1--and assuming that all automobiles in the queues are in the hot stabilized mode during the morning peak--the air quality impacts were analyzed. These are also shown in Table 4-1. The national averages for cold and hot starts were used in representing evening peak conditions.

4.2.3 Carbon Monoxide Increases - Intersection Impacts

An analysis of the change in CO concentrations at intersections designated by the Massachusetts Department of Environmental Quality Engineering (DEQE) as CO Hot Spots was undertaken as part of this EIR. A CO Hot Spot is an intersection which has high concentrations of CO. Five intersections were considered in this analysis based on a likelihood of increased emissions.

Increased traffic volumes were assigned to local streets based on the number of "within downtown," "core-to-downtown," and "corridor-to-downtown" trips generated by the fare increases.

AM Peak Period	Central Artery to I-93&Rt. 1	Storrow Drive to I-93 & Rt. 1	Sumner/ Callahan Tunnels	Southeast Expressway	Mass. Turnpike	Storrow Drive
Increased Traffic	3,195	1,220	370	3,650	3,160	1,070
Free Flow Speed	50 mph	40 mph	40 mph	55 mph	55 mph	40 mph
Average Queue Speed	10 mph	5 mph	5 mph	25 mph	55 mph	25 mph
Change in Miles of Queue	0.12	0.037	0.007	0.214	No Change	0.20
Peak Volume	11,525	8,080	10,495	26,584	16,250	10,875
*Additional HC Emissions	1.43	0.69	0.17	2.41	-	0.83
*Additional CO Emissions	25.82	13.09	3.14	38.52	-	14.72
*Reduction in NO_x	0.41	0.07	0.02	1.38	-	0.52

PM Peak Period	Central Artery to I-93&Rt. 1	Storrow Drive to I-93 & Rt. 1	Sumner/ Callahan Tunnels	Southeast Expressway	Mass. Turnpike	Storrow Drive
Increased Traffic	2,740	1,675	370	3,655	3,160	1,070
Free Flow Speed	50 mph	40 mph	40 mph	55 mph	55 mph	40 mph
Average Queue Speed	10 mph	5 mph	5 mph	25 mph	55 mph	25 mph
Change in Miles of Queue	.25	.905	.0211	0.435	-	0.43
Peak Volume	11,525	8,080	10,495	26,584	16,250	10,875
*Additional HC Emissions	4.04	2.15	0.48	4.64	-	1.37
*Additional CO Emissions	92.31	52.75	11.68	109.79	-	44.40
*Reduction in NO_x	1.20	0.24	0.05	3.64	-	1.47

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*Tons/Year.

SUMMARY OF IMPACTS OF INCREASED QUEUES

TABLE 4-1

These trips were allocated to super zones as defined by the 1977 Central Artery Origin-Destination Study. Volumes were then distributed to the five intersections being analyzed based on likely travel routes.

The CO Hot Spot Analysis technique used was EPA's Volume 9 method as modified by DEQE. The technique considers traffic characteristics such as volumes, intersection configuration, signal timing, speeds, meteorological conditions, and dispersion rates. Worst case urban meteorological conditions of low wind speed, low vertical mixing, and neutral air mass stability are assumed. The receptor site is located on the approach with the longest traffic queue and is situated at the point along the queue where the worst-case, wind-roadway angle will produce maximum impact from this queue's emissions. All traffic on an intersection approach is assumed to be divided equally among the available lanes; hence, all lanes on an approach will develop queues of equal length.

The procedure computes emissions both from vehicles that travel through the analyzed location without delay and from those that are delayed and, therefore, generate emissions at a higher rate. These "free-flow" emissions and "excess" emissions are added to the areawide background concentration to derive the CO concentration at the location.

Employed to estimate both eight-hour and one-hour concentrations of CO, the model was used to estimate conditions with and without the fare increases. The results of the analysis are shown in Table 4-2. (A description of the CO Hot Spot Analysis parameters is provided in Appendices F-5 and F7.)

None of the intersections exceed the one-hour standard of 35 ppm, although conditions at Leverett Circle approach 30 ppm. The most notable changes were projected at the intersection of Cambridge and Staniford streets (+4.8 ppm) and on Beacon Street at the Embankment Road (+2.75 ppm). The eight-hour standard of 9 ppm would be violated at three intersections with the increased traffic volumes, according to the analysis. Both Leverett Circle and the Boston University Bridge sites exceeded the levels before the fare hikes. Conditions along Blue Hill Avenue would deteriorate to the point where the standards would be exceeded at the designated intersection.

4.2.4 Atmospheric Lead Level Impacts

An effort was made to estimate the amount of lead emissions from automobiles attributable to the fare increases. According to a number of sources the amount of auto-caused, lead-particulate emissions is dependent on a range of environmental and vehicle-operating conditions, including: vehicle speed, driving conditions, lead content in gasoline (which itself can vary by season, region of the country, and grade of gasoline), quantity of gas consumed, fuel economy, mileage accumulation, and distance traveled. Other factors having an effect on atmospheric lead

	8-HOUR (ppm)			1-HOUR (ppm)		
Intersection	Without Fare Increase	With Fare Increase	Change	Without Fare Increase	With Fare Increase	Change
Leverett Circle peak +180 vph 8-hour +105 vph	10.85	11.43	+.58	29.31	29.75	+0.44
Cambridge & Staniford Sts. peak +205 vph 8-hour +118 vph	7.56	8.22	+.66	16.17	20.97	+4.80
Blue Hill Ave. & American Legion Hwy. peak +100 vph 8-hour +60 vph	8.87	9.17	+.303	21.01	21.77	+0.76
B.U. Bridge & Commonwealth Ave. peak +90 vph 8-hour +50 vph	9.79	9.79	+.00	27.73	28.33	+0.60
Beacon St. & Embankment Rd. peak +80 vph 8-hour +47 vph	8.57	8.64	+.07	23.39	26.14	+2.75

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vph = vehicles per hour
ppm = parts per million
*Figures include a background CO concentration of 3.0 ppm.

CO ANALYSIS* (1982)

TABLE 4-2

emissions are, of course, orientation of the prevailing winds and additional non-auto sources, such as industrial processes from smelting to the production of Portland cement, residential fuel combustion, and dust from roads and tilled land.

A certain amount of controversy surrounds the actual amount of atmospheric lead contributed by automobiles. A report from EPA puts the figure at 90 percent. Although there is some debate about that figure, most studies do agree that the amount of lead emissions is steadily dropping as the number of vehicles using leaded gasoline declines. EPA claims there has been a 400 percent decrease in the calculated lead emission factor from 1975 to 1982 and another 730 percent reduction will take place before 1990.

Using a method which takes into account vehicle mix, fuel consumption, lead content of gasoline, and the amount of lead emitted from vehicles, an estimate of vehicular lead emission in the Boston area has been developed. It is keyed to the estimated increase in vehicle miles traveled regionally. An increase in VMT of 230,100 will add approximately 34 pounds of lead to the region's atmosphere daily, or approximately 4.67 tons per year. This can be further categorized by subregion (see below) using grams/vehicle mile multiplied by a factor of .0676.

Area	Daily VMT	Grams of Lead
North Shore	18,800	1,270.88
North	30,900	2,088.84
Northwest	27,600	1,865.76
West	30,900	2,088.84
Southwest	25,400	1,717.04
South Shore	51,800	3,501.68
Within Downtown	9,600	648.96
Within Core	35,100	2,372.76
	230,100	15,554.76 = 34.3 lbs.

Given the amount of variability in vehicle condition and environmental factors, this should be treated as a rough estimate of lead emission. it is also based on a vehicle mix and fuel economy standards of vehicles from 1961-1980; we may assume that 1981 and 1982 model vehicles have reduced lead emission and that more old, lead-fueled vehicles have been taken off the road.

Another factor which has not been determined, but which could be considered, is the effect of "re-entrained" road dust containing lead which is disturbed by passing vehicles. EPA states this figure would be under .01 grams per vehicle mile by 1980 and further decreased by 1982 due to reduced use of leaded fuels. Appendix F-6 includes information on the way these figures were calculated.

4.2.5 Relation to Air Quality Standards

As already mentioned, localized CO conditions are expected to deteriorate as a result of additional automobile travel due to the fare increase. The eight-hour standards would be exceeded at three of the five intersections studied. One of which would be due directly to the added impact of the fare increase. These should, however, represent the most significant changes in the CO concentrations in the region, due to the fare hike.

It has also been shown that emissions of hydrocarbons will increase, due to both increased VMT and congestion. DEQE has estimated the expected annual emissions of HC in the Boston region for 1982 and has identified the target reduction to bring the region in compliance with the National Ambient Air Quality Standards. Currently, the region is exceeding the standard; the fare increases exacerbated the situation by adding hydrocarbons at the rate of 200 tons per year.

The State Implementation Plan, which outlines the steps the state will take over the next five years to attain the air quality standards, is currently being revised. The Transportation Element of the SIP (TE/SIP) for the Boston region is required to indicate how the region will reduce emissions to reach the target reduction identified by DEQE. The increase in emissions due to the fare increases is less than half of one percent of the reduction needed by the transportation sector to attain the standards.

For the Boston SIP analysis area, a 35-percent reduction in 1980 emissions is required to assure compliance with ambient air quality standards.

The NMOC (HC) emissions inventories for the Boston analysis area indicate that there will be a 39-percent reduction in 1980 emissions by 1987 if all controls spelled out in the 1979 TE/SIP are implemented as presently scheduled, including Inspection and Maintenance (I&M), all stationary controls, and the Federal Motor Vehicle Emissions Control Program Emissions for 1987 for the MAPC region are estimated at 39-percent below that of 1980.

However, this margin of the announced attainment level without additional controls is narrow. The fare increase further narrows this margin. Should this margin hold, it is important to note that simply balancing on the edge of attainment, while meeting requirements, would act as a constraint on the region's future growth.

The state's ability to accept additional pollution from future industrial or transportation sources will be limited if attainment is narrowly met. Therefore, whether the state is at or below attainment, the TE/SIP's emission reductions, combined with the proposed additional SIP reductions, will act to improve the state's position regarding attainment and growth.

These results indicate that the Boston urban area, as well as the MAPC region, will be in compliance with air quality standards by 1987 if all controls spelled out above are implemented as scheduled.

Any added reduction resulting from transportation control measures to be implemented will increase the margin by which the region will be in compliance.

4.3 ENERGY IMPACTS OF THE FARE INCREASE

There are numerous energy consumption impacts in the diversion of riders from transit to private automobiles on both a primary and a secondary level. Initially, assuming an average auto energy efficiency of 15 miles per gallon and an estimated increase in VMT of 69 million miles per year, motor fuel consumption would increase by 4.6 million gallons/year, due directly to the fare increases. This represents approximately 0.2 percent of the annual motor fuel consumption in the state.

While there would be a passenger reduction on the MBTA, it is questionable whether significant energy or fuel savings could be realized by the MBTA. This is due to the fact that even a significant reduction of riders would not affect the fixed energy usage (29 percent of total usage) required to operate the entire system and would not have an effect on total vehicle mileage unless new schedules were implemented to reduce unused service.

It should be noted that the changes in air quality or energy consumption do not consider that the reduction in riders might cause reduced bus VMT. In fact, the number of bus miles operated by the MBTA has been decreased, and this is attributed to rescheduling and service decreases previously planned and not directly related to the fare increase.

This analysis has attempted to isolate the impacts of fare increases and so reduced bus VMT is not considered. Secondary, energy impacts are also anticipated: the traffic congestion resulting from diversions will increase the original yearly estimates of additional fuel consumption by 11 to 15 percent. Appendix F-3 details the increases in energy use. In the analysis presented there, it is concluded that the congestion would require an additional 689,000 gallons of fuel per year. This would produce a total increase in motor fuel consumption of approximately 5.4 million gallons per year.

4.4 NOISE IMPACTS OF THE FARE INCREASE

Generally, noise pollution is a highly localized problem and, as such, the fare increases on the MBTA should have a negligible impact on noise levels. The increase in traffic volumes at a given location is not large enough to create a noticeable change in the noise levels. Noise is measured on a logarithmic scale to replicate changes discernible by humans. It would take a doubling in the traffic volumes to produce a noticeable change in the noise levels heard. The increased volumes are not of this magnitude.

This, however, assumes that the diverted drivers remain on the same paths currently used. It is probable that increases in traffic congestion would change circulation patterns and divert some additional trips through local streets, thus increasing noise levels in some local areas. A much more detailed network modeling effort would be required to simulate all probable intersections which would be impacted.

Since vehicle noise is also a function of speed, congested conditions might also change perceived noise levels. Noise levels generally are lower for automobiles at lower speeds; truck noise levels increase at lower speeds. No attempt has been made to quantify these effects, since heavy trucks comprise a small percentage of vehicles in the queues.

5.0 ALTERNATIVES

This section identifies and analyzes several alternative actions to the fare increase that could be taken by the MBTA. The No-Action alternative presents the case that would have occurred had a fare increase not been granted. The Implemented Action represents the fare increase of August 1981. In most cases, the impacts of the fare increase have been isolated from those associated with service cuts, which also occurred in 1981. Several alternative fare structures have also been presented including peak period pricing, discounted transfers, and reduced rates for certain groups. Alternative fare payment methods have also been addressed.

Following the discussion of the individual fare alternatives, a comparative analysis is presented.

5.1 NO-ACTION ALTERNATIVE

For the purpose of this EIR, the no-action alternative maintains fares at pre-August 1981 levels. According to an estimate presented in the Environmental Notification Form (ENF), July 7, 1981, an additional $19 million was needed to get through 1981 without further service reductions. Increasing the fares was cited as the only feasible way of raising the necessary funds. The MBTA stated that if a fare increase were not implemented by August 1, 1981, serious repercussions were inevitable. The two possible results of inaction cited in the ENF were: a reduction of all service levels shortly after August 1; or, the termination of all service for approximately the months of November and December. The latter situation would have severe impacts on both users and on-users of the MBTA.

At that time, the MBTA did not further detail the extent of the service cuts needed to maintain some service throughout the remainder of 1981. The Authority has since then identified the types of changes that would be necessary to comply with a budget level $15 million short of what it needs. These are described in Section 5.2 as part of the Implemented Action. Generally, the MBTA would have to cut bus routes, reduce maintenance personnel, reduce rapid transit service, and modify some employment practices concerning part-time work.

If the August fare increase had not been implemented, the 1982 budget shortfall would have been approximately $35 million over the 1981 level. In other words, more changes would have been needed at the MBTA to reduce service and associated personnel costs by $35 million. Since over one-third of all costs are fixed, the reductions would have had to affect service.

5.2 IMPLEMENTED ACTION

Implemented actions included the August 1981 systemwide fare increase coupled with changes in the level of transit service. Local bus fares increased from 25 cents to a zonal system with a 50 cent base fare. The base rapid transit fare rose from 50 cents to 75 cents. Express bus fares were incresed to a maximum of $1.50/trip. Service reductions in the form of cancelled routes, shortened routes, increased headway, reduced hours, and decreased express bus service were instituted.

A detailed description of these actions was presented in Section 2.0 of this report; the impacts on ridership and the environment were addressed in Sections 3.0 and 4.0, respectively.

5.3 ALTERNATIVE FARE STRUCTURES

This section presents a series of alternative fare structures for the MBTA. In general, these alternatives are directed toward increasing revenue or ridership associated with specific groups of users. The programs identified would affect commuters, senior citizens, low-income riders, or other target groups depending upon the alternative action.

In each case, the alternative is described and past experiences with the programs, either in Boston or in other cities, are reviewed. Where possible, the likely impacts of these actions on ridership and revenue are quantified. The feasibility of implementing the alternatives and the operational and equipment changes needed on the MBTA are addressed.

5.3.1 Peak-Period Pricing

Peak-period pricing is simply the policy of maintaining lower transit fares during off-peak hours (generally 10 AM to 4 PM and after 7 PM on weekdays and all day Saturday and Sunday) than during peak hours. Such systems may be implemented by either lowering off-peak fares or raising peak fares. These pricing policies are sometimes applied only to certain groups within the general population, most frequently to the elderly.

Many systems throughout the country have experimented with peak-period pricing, although few large systems have maintained such fares.* The impact of these policies on ridership differs

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*Dygert, Holec, and Hill, Public Transportation Fare Policy, for USDOT, (Washington, DC: Peat, Marwick, Mitchell and Company) December 1976.

Alternative Fare Structures	Description of Measures
• Peak Period Pricing	Raise fares during peak hours for all full fare riders.
• Reduced Rates for Transfers	Examine the viability of reduced rate transfer system for the approximately 40 percent of all MBTA trips which require a modal change.
• Lower Fares for Downtown Travel	Reduce fare within the core area in an attempt to increase ridership on trips currently made by other modes.
Alternative Fare Payment Methods	
• Electronic Fare Collection	Through the use of electronic equipment, tickets can become credit towards a certain amount of transit service. A more diversified fare structure could also be established and administered.
• Bulk Sale of Tokens	Reduce the cost for riders buying tokens in bulk to aid in reducing lines at token booths and to provide incentive of a discount for regular riders for whom passes are impractical.
• Self-Service Fare Collection	With the assistance of automated ticket dispensing equipment and inspectors doing spot checks on riders, much of the personnel costs involved in the current fare collection could be eliminated.

TABLE OF ALTERNATIVES

TABLE
5-1
1 OF 2

Legislative Programs	
• Subsidy Programs	The current "less than full" fare categorical discounts for special groups (i.e., students, elderly, handicapped) would be administered by social service agencies and school districts so that costs of subsidy would be assigned more equitably and that policies for the granting of subsidies could be established to prevent abuse.
• Alternative Funding Programs	To find ways of generating funds from other sources than the current mix of governmental and revenue sources, including sales tax, gas tax and auto use charges, and payroll taxes.
• Cost of Living Indexing	Establish a policy in which the fare is tied to cost indices with regular adjustment periods.

TABLE OF ALTERNATIVES

TABLE 5-1
2 OF 2

widely from one city to another. Austin, Texas, decreased off-peak fares by 50 percent, and ridership increased 30 percent. When Louisville, Kentucky, did the same thing, ridership increased only 7 percent.* Madison, Wisconsin, offered free off-peak rides for one week, and ridership increased by 93 percent.

The primary goal of peak-period pricing is to increase ridership during off-peak hours. When fares are increased systemwide, the impact is felt most strongly during off-peak hours when traffic congestion and vehicle crowding are already at their lowest. By instituting a system in which off-peak fares are lower, new riders may be attracted, and those already using the system may be induced to switch from peak- to off-peak travel. These results were measured in two cases of off-peak reduced fares in Denver and in Trenton.

In Denver, the off-peak fare went from 25 cents to free; the peak fare had increased from 35 cents to 50 cents just prior to the demonstration.** These changes resulted in an 87 percent increase in off-peak ridership and a 24 percent decrease in peak ridership. Net ridership increased 34 percent. In Trenton, off-peak trips became free (from 15 cents), and peak fares remained at 30 cents. The result was a 45 to 50 percent increase in off-peak travel, an 8 percent decrease in peak travel, and a net ridership increase of 10 to 15 percent. Therefore, both of these programs increased ridership as well as shifting some riders from peak hours to less crowded off-peak hours. The concomitant decreases in revenue have not been documented.

Another approach to reduced off-peak fares is to lower fares on weekends. In 1974, the "Save on Sunday" program was instituted in New York City. The program offered two rides for the price of one on Sundays only. Sunday ridership increased by approximately 37 percent overall.***

In general, peak-period pricing policies are fairly simple to implement. No investment is required from the transit facility outside of that required to launch a public information program informing riders and potential riders of the change. The obvious major drawback of reducing off-peak fares is that it necessarily requires a decrease in net transit revenue. A study of six transit systems in New York by NYSDOT concluded that no combination of fares could increase both revenue and ridership.* They also found that no combination of fares on the NYC subway will increase ridership by 2 percent without cutting revenues by at least 6 percent. (The study group also warned that ridership losses are not reversible; it is best to encourage different fare policies that decrease ridership by no more than 5 percent because lost riders are difficult to win back.) Thus, while any reduced fare program will undoubtedly stimulate ridership, a significant loss in revenue must be expected as well.

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*Goodman and Green, Low Fare and Free Fare Transit, for UMTA (Washington, DC: Peat, Marwick, Mitchell, and Company) December 1976.

**Barton-Aschman Associates, Incorporated, Traveler Response to Transportation System Changes, Second Edition, for FHWA (Washington, DC: Barton-Aschman Associates) July 1981.

***Mayworm, Lago and McEnroe, Patronage Impacts of Changes in Transit Fares and Service, for UMTA (Washington, DC: Ecosometrics, Incorporated) September 1980.

The Boston Experience

The MBTA has had some experience with peak-period pricing in its Dime Time Experiment. In April 1973, fares on the Blue, Red, and Orange lines, as well as the Central Green Line, were reduced from 25 cents to 10 cents between 10 AM to 1 PM on Monday through Friday. The fare on the Red Line Extension to Quincy was reduced from 50 cents to 25 cents. In March of 1974, Dime Time was extended to include an extra hour on weekdays (until 2 PM) and all day Sunday. The experiment was terminated in August 1975. A study by Decision Research, Incorporated, in 1974, was unable to quantify any gain in ridership.**

While Dime Time did cause some shift in ridership from the peak to off-peak period, total ridership remained relatively level (+2 percent).

The elderly, as a group, are sensitive to change in fare. During the period in which Dime Time was in effect, the elderly were paying one half the adult fare of 25 cents. Dime Time represented a minor fare reduction for this market segment. Starting in August of 1981, the elderly have been allowed to ride free in the period between the AM and PM peaks. This absolute reduction in fare has created a substantial gain in elderly ridership.

Reduced off-peak fares for the elderly are offered by most transit systems in the United States. The federal government requires these fare reductions in order to qualify for Section 5 funding. Lower fares for those 65 and over who reside in the MBTA district are required by law. As of August 1969, Chapter 161A of the General Laws required that elderly riders pay no more than one half the full adult fare on both subways and surface lines.

Impact of Off-Peak Fares for the Elderly

Since August 1981, elderly and handicapped riders have been able to use the system for free between 9:30 AM and 4:00 PM on Monday through Friday. This policy increases the number of elderly riders and decreases revenue for the MBTA. The cost of this program is equivalent to the dollar value of the fares not paid by elderly riding for free.

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*Hartgen and Weiss, "Different Time of Day Transit-Fare Policies: Revenue, Ridership, and Equity" in Transit Planning and Operations, Transportation Research Board Record 625 (Washington, DC: Transportation Research Board) 1977.

**Decision Research Corporation, Dime Time Ridership, Study No. 2 for MBTA (Wellesley Hills, MA: Decision Research) June 1974.

About 59,000 elderly riders use the system on an average weekday and pay over $9,000. If all of these riders paid half fare, the receipts would total about $25,000 per day. The difference, however, does not accurately represent the value of the lost revenue, because the fare would cause some riders to leave the system. No data is available regarding the response of elderly riders to new fares after a period of free fares. One might expect, however, that the new ridership level would be similar to that which would have occurred had fares for the elderly increased in August when the other fares did, without an intermediate period of free fares. Using the 1980 elderly ridership (approximately 45,000/day), the old fares, assumed new fares (equal to one half of adult fares), and an elasticity of 0.14, an expected ridership level of about 32,000 people per day can be calculated.

It, therefore, seems likely that if fares for the elderly had increased to one half of the new full adult fare, there would be approximately 32,000 elderly riders per day paying about $14,000. This means that the free fare program costs about $5,000 and increases ridership by the elderly by 27,000 trips each day. These values translate into a net annual loss of $1.6 million and a gain of about 8 million riders.

Finally, a peak period pricing strategy that bears consideration is one of raising fares during the peak hour. This policy would take advantage of the low fare elasticities exhibited by riders en route to or from work during the peak hour. Since it costs more to carry passengers during peak hours and since peak period riders often place a higher value on their trips than off-peak passengers, these riders are good candidates for increased fares.

In order to estimate the impact of such a program on MBTA ridership and revenue, several assumptions must be made. First, assume that the fare policy adopted required a "peak-period premium" of 10 cents on each ride (a fare increase of about 15 percent). Further, assume that 57 percent of all transit trips are made during the peak periods and that an elasticity of 0.16 (Ecosometrics) is applicable to these trips. Therefore, a 10 cent peak-period premium would result in an annual loss of almost 2 million riders and a net gain of nearly $6.5 million. If, however, the diverted riders simply shifted from peak to off peak, thus avoiding the surcharge, no riders would be lost and revenue would increase by about $7.8 million. The actual result of an increase in peak-period fares should fall somewhere between these two figures.

5.3.2 Reduced Fare Strategies for Special Groups

Offering a reduced fare to a group of riders will generally have two effects. First, it will decrease the amount of revenue collected from each individual and from the group as a whole.

Second, it will stimulate ridership, increasing patronage of the system by members of the group.

The policy of establishing modified fares for certain groups of riders can be justified in several different ways. Many transit properties offer reduced fares to groups that are considered less capable of paying high fares, such as the elderly or the handicapped. Others offer low fares meant to encourage trips that are felt to contribute to the "public good," such as school trips by students. Also, many transit properties seek to take advantage of the lack of responsiveness of certain groups to fare changes. Some groups, commuters for example, have such an inelastic demand for transit that by raising their fares, system revenue can be increased significantly without causing a major disruption in ridership.

In order to evaluate reduced fare policies, potential methods for defining these groups of riders must be examined. The effect these policies would have on the transit system in Boston can only be estimated for those cases for which local data is available and experience in other cities has been documented.

An obvious criterion by which transit riders may be divided is age. Senior citizens enjoy reduced fares in most U.S. cities and towns; in Massachusetts, such a policy is required by law. The effect of reduced fares for the elderly is described in the preceding section of this report (see Section 5.3.1).

Another age group frequently singled out for special fares is children. Low fares are justified both by virtue of the limited funds available to children and because many trips made by children are school trips. School trips are popularly considered to merit some form of subsidy. The exact number of transit trips being made by students and children in Boston is unknown. A recent CTPS estimate places the number at approximately 12 million trips per year. The trips bring in slightly over $4 million each year. If students were forced to pay full fare for these trips, it is estimated that the number of student trips would fall to close to 9.5 million per year with a total revenue of close to $8 million. This represents a loss of over 2.5 million student trips with a concomitant gain of $4 million.

One of the few studies of the travel behavior and travel needs of young city residents was done in 1968 by Carnegie-Mellon University.* The study analyzed travel patterns and travel desires of 7th, 10th, and 11th graders at five Pittsburgh high schools with student bodies of varying socio-economic status and racial composition. The study revealed that:

(1) The 'typical' student makes four trips a day between 3 nodes that are a mile apart;

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*Latent Demand for Urban Transportation, Transportation Research Institute, Carnegie-Mellon University, Pittsburgh, PA, 1968.

(2) younger students travel less frequently, within a smaller urban area, and to fewer destinations than older students;

(3) female students travel less frequently, within a smaller urban area and to fewer destinations than males (except for 7th grade females);

(4) non-whites travelled further but within a smaller urban area than whites;

(5) the 'typical' student desired to make, on a typical weekday, two additional trips (i.e., two more than he now makes).

If one were to accept the results of this study, it is clear that urban youths use transit systems and desire to use the transit system for more than just school trips: for work, sports, social engagements, etc. It should be recognized that for some urban youths, the MBTA is the only transportation alternative. Unfortunately, the data is not sufficient to predict the effect of 1/2 fare for children under 18 at all times.

There are, however, two experiments of free-fare transit* at all times which had results that may relate to reduced student fares. The transit systems of Denver and Trenton reported significant increases in rowdyism and vandalism on transit vehicles and at stations when the free-fare system was in effect. The most surpising result of the Trenton project according to a report, "was a groundswell of driver and media reaction to an increase of rowdiness, vandalism, and harassment on the buses and in a suburban shopping mall served by the demonstration's free rides." Trenton's response was to increase security forces and reduce the free hours. Similar events took place in Denver, where reports of disruptive incidents correlated with the free-fare period. This is not to suggest that half-fare for those under 18 at all times would have a similar effect in Boston, but it is a subject for further study.

Another group that might be considered eligible for reduced transit fares is low-income riders. Although transit riders with low incomes are generally fairly unresponsive to fare increases (their demand is inelastic), this is frequently due to the fact that they are often captive riders as well. When low income riders are forced to pay more to use the transit system, they increase the already disproportionately large fraction of their income that must be devoted to travel expenses. The effect of subsidizing transit ridership for low income users in Boston is difficult to measure. Lack of information regarding the incomes of transit users and the general travel patterns of the poor presents a major obstacle. The presence of large numbers of college students in the Boston area also compounds the problem of the definition of low income.

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*A. H. Studenmund, "Interim Analysis of the Free-Fare Transit Experiments," A. H. Studenmund in Transportation Research Record #719, Transit Development (Washington, DC: Transportation Research Board) 1979.

Perhaps the best way to evaluate the potential for subsidizing low income MBTA riders is to estimate the number of program participants based on the number of residents eligible for the Food Stamps program or Aid to Families with Dependent Children (AFDC).* In the Boston area, the Food Stamps program has roughly one-third more participants than AFDC does. In order to provide an estimate of the maximum revenue loss and ridership gain associated with a subsidy program, eligibility for food stamps will be considered as the basis for transit subsidies as well. There are approximately 92,000 households in the Boston area that participate in the Food Stamp program. They constitute approximately 9.5 percent of the region's households. The 1978 MBTA ridership survey indicates that the percentage of riders from low income groups is significantly higher than the percentage they represent in the general population. According to the survey, 23.8 percent of the MBTA passengers had household incomes under $8,000 in 1978, whereas 12.8 percent of all Boston SMSA residents are in this income group. Thus, it appears that MBTA ridership from this group is 86 percent larger than might have been predicted based on general population statistics. If it is assumed that this relationship holds true for potential MBTA riders from families in the Food Stamp program, then the reduced fares would apply to 17.7 percent of all transit trips. Assuming a fare elasticity for low income riders of .19 (Ecosometrics, 1980) and a mode-split pattern similar to that of all transit riders in general, half-price fares for members of low income households would generate approximately 1.3 million trips per year with a total annual revenue loss of about $4.1 million. Revenue losses and ridership gains would be smaller if eligibility for the reduced fare were limited to AFDC recipients rather than Food Stamp program participants or if the reduced fare were something larger than half the full adult fare. Revenue losses are probably overstated in this example because low income children and elderly are already paying reduced fares. A description of a program where the state could subsidize these riders is provided as a potential mitigating measure.

A brief mention should also be made of reduced fare programs aimed at riders with very elastic responses to fare changes. An example of this type of behavior is travel that is not CBD-oriented. Travelers bound for the downtown are generally half as responsive to change in fares as others are. Theoretically, routes with neither origin nor destination in the downtown area could be subject to lower fares. This policy would help to minimize the significant ridership losses associated with fare increases. There is not enough data available to quantify the impact of such a program on MBTA ridership or revenue.

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*A review is presented in an EOTC memorandum, "Estimate of Cost of Fare Subsidies for Low Income MBTA Riders," July 29, 1980.

5.3.3 Reduced Rates for Transfers

Programs that offer reduced rate transfers between vehicles on a single transit system can be designed in a number of ways. Transfer fees may range anywhere from full fare to free. Reduced rates may be offered on transfers from bus-to-bus, rail-to-bus, or rail-to-rail. Some transit facilities discount all transfers between vehicles while others limit the special fares to a small market segment such as express bus-to-rail transfers.

Very few properties have full-fare transfers on buses. Transfer fees are fairly uniform nationally and generally fall between zero and 10 cents. A small fee is often employed in order to prevent abuse of the system; riders are less likely to collect transfers with the intent of giving them away or selling them if some fee is charged. The distribution and collection of slips may slow the entrance or exit of passengers and thus cause some system delays.

Transfer fees on other fixed rail systems are less uniform. Fees are commonly set at either full fare or half fare or they are free. The design of many rail facilities limits the feasibility of less than full fare transfers. Vehicle delays and increases in dwell times are generally less of a problem on rail systems than on buses.

Several mechanisms are available for actually implementing a reduced-fare transfer system. Slips from bus drivers or booth men, passes, machine slips, and limited access transfer areas are all possibilities. Bus transfers usually use driver-distributed slips, and therefore, these programs frequently have lower costs than similar rail programs.

The most marked effect of a reduced-rate transfer policy is the loss of revenue involved. Associated with this loss, however, is a significant increase in transit ridership due to the reduced fares. In most cases, those reduced rates are being offered to riders whose previous linked trips were among the most expensive per mile in the system. For this reason, the reduction in system revenue can often be justified as an equity measure.

There are a number of problems associated with reduced-rate transfer policies that are unrelated to revenue. One is the problem of checking the validity of the transfer slips. Either extra gatemen must be hired or bus drivers would need to increase their dwell time at some stops to examine the slips. Another problem is the cost of the slips themselves; a 1976 study* placed their value at $225,000 per year in Boston. The machines that dispense the transfer slips also represent a significant capital outlay. Passenger wait times can be increased by lines at dispensing machines and collection points. In other words, there are many methods by which reduced-rate transfer policies may be implemented; none of them are flawless.

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*Massachusetts Bay Transportation Authority, Report of the Fare Review Task Force, Phase III, Boston, Massachusetts, November, 1976.

In order to evaluate the ridership and revenue impacts of a reduced-fare transfer policy in Boston, some estimate of the number of transit riders who make transfers on the MBTA must be calculated. The 1978 MBTA Systemwide Survey indicated that approximately 40 percent of all trips require a transfer between modes and about 5 percent require a transfer from one bus to another. A large number of reduced-fare transfer configurations are possible. The repercussions of a few will be looked at here.

One popular design for reduced-rate transfers is that of offering a free transfer from subways to buses. The typical adult paying full fare now pays $2.50 for this trip, but would pay only $2.00 under this system. If it is assumed that half-fare riders are also offered the free bus trip and passes are discounted accordingly, combination trips might be expected to increase by about 8,000 per day. This translates into a net gain of over 2 million riders each year with an annual revenue loss of about $8 million. If a small fee were charged for each transfer slip, the revenue loss and ridership gain would, of course, be slightly smaller.

Another option that merits consideration is that of free transfers between buses only. This policy would prevent riders from being penalized simply because their trips did not coincide with designed bus routes. Approximately 24,000 people make transfers from one bus to another on an average weekday, based on the updated results of the 1978 MBTA Systemwide Survey. Free transfers would, therefore, increase the annual number of bus-to-bus transfers from about 6.9 million to about 7.9 million. At the same time, revenue from these passengers would decrease from nearly $6.9 million to close to $4 million.

The number of possible reduced-fare transfer plans is almost limitless, yet any plan by necessity implies a gain in ridership as well as a loss in revenue. The different fare configurations can alter the magnitude of these changes and can target certain groups within the transit riding population as beneficiaries.

5.3.4 Lower Fares for Downtown Travel

The reduction of transit fares in downtown areas is an increasingly popular alternative to flat fare systems. Many cities that initially launched such programs as experiments have adopted them as part of their permanent fare structure. Revitalization of the downtown is frequently as important a goal for these programs as increasing ridership on the transit system.

Basic to the implementation of free and reduced-fare downtown distribution systems is the definition of a "downtown zone." Many cities focus on tourist areas, some on the retail district, and others cover most of the central business district. Reduced fares may be implemented on existing routes that travel to or through the downtown, or special downtown loop services may be established. Low fares on downtown loops may reflect a low cost due to limited route length and high density of use and the lower incremental value of such trips to the individual user. In some areas, downtown merchants contribute to the financing of these systems.

The objectives of these reduced fare programs generally include revitalization of the downtown area, including an increase in retail activity, reduced traffic congestion, decreased pollution, increased transit patronage, and an improvement in the image of public transportation. The single largest negative impact of such programs is the loss of revenue from those riders already making trips within the CBD. Another problem is that the service may slow systemwide bus operations slightly if increased ridership lengthens dwell times significantly. Systems that have instituted such programs seem generally satisfied, however.

Two cities that offer fare-free downtown distribution are Albany and Seattle. In November 1978, the Capital District Transportation Authority (CDTA) eliminated transit fares in a two-thirds square mile zone in downtown Albany. The free-fare program was in effect from 9 AM to 3 PM weekdays and from 9 AM to 6 PM on Saturdays. Downtown weekday ridership tripled; Saturday ridership in the CBD increased five-fold. Downtown retail sales also reversed a long-term decline and increased almost 10 percent. The two-year demonstration program has been continued indefinitely, although the hours have been trimmed slightly. A merchant's association is jointly financing continued service with CDTA and the City of Albany.

In 1973 in Seattle, METRO Transit began offering free fares in a one-half square mile zone downtown during all hours and all days of the week. The original zone covered primarily tourist retail areas, but has been expanded to include urban renewal and some residential uses. Intra-CBD ridership has tripled since the program began. METRO Transit discovered several interesting facts about their free downtown distribution system. First, most of those who made their trip prior to free fares walked (45 percent) or rode the bus (41 percent). The impact on traffic and parking has, therefore, been negligible. Second, free-fare passengers generally have higher incomes than other transit users.

Third, most of the new trips were between 11 AM and 2 PM and involved some kind of purchase. Seattle's free-fare program has also been continued indefinitely.

The applicability of these reduced-fare downtown distributor systems to the situation in Boston is limited. Most of the transit service offered within the downtown is subway service. It would be very difficult to implement a system whereby transit riders could ride between downtown stations at a reduced price. It would probably be necessary to give a timed and dated receipt to those who board downtown; the receipt could then be exchanged for cash if the rider also exited downtown. This type of system is used for local trips on the Quincy Branch of the Red Line. Abuse of either system would be impossible to prevent. There would undoubtedly be a certain number of people exchanging receipts or giving them away. The costs involved, including increased manpower or machinery to give out receipts, gatemen to check them and hand out refunds upon exit, and the costs of the receipts themselves.

Another possible option might be the introduction of reduced-fare buses just for downtown circulation. The MBTA offered a bus from South Station to Downtown Crossing during the Christmas holiday season in 1981 for 25 cents. The adoption of this type of program on a large scale would be prohibitively expensive.

The revenue loss and ridership gain resulting from a reduced-fare downtown distribution system would be directly related to the degree of subsidy applied to the downtown trips. No good data is available on the number of intra-CBD trips currently being made in downtown Boston.

5.3.5 Comparison of Alternatives

The projected impacts of the various fare structure alternatives are summarized in Table 5-2. Factors that cannot be quantified, such as "ease of implementation," were rated on an ordinal scale. Comparison of the different programs shows that for a given change in ridership, a number of different revenue and VMT changes may be expected depending on the specific group within the population that is targeted by that program. For example, losing a certain number of elderly riders would have a smaller impact on revenue than losing the same number of full-fare riders. This is illustrated in the peak period surcharge alternative in which about $7 million in additional revenue is expected while only 2 million annual riders are lost. The relationship between VMT and ridership varies in a similar way; the increase in VMT for a given loss in commuters is nearly twice as large as it would be for the same number of students. While the actual values listed in this table may not be definitive, they offer a good basis for comparing the results of the fare structure programs.

5.4 ALTERNATIVE FARE PAYMENT METHODS

In addition to the self-service alternative described in detail previously in Section 5.3, several other alternative payment systems have been considered in this study. Fare collection systems currently in use in the United States range from completely manual operations to fully-automated systems. The type of fare collection system is dependent, in part, upon the type of fare structure, such as flat rates, zonal fares, or mileage-based fares. The type of fare structure, in turn, dictates what type of collection system is needed.

Currently, fares are paid on the MBTA by using one of four methods: cash, token, prepaid pass, or ticket. Tickets are used only on a few express buses; cash, tokens, or passes are accepted on surface vehicles. Access to rapid transit lines requires either a token or a valid prepaid pass. Prepaid passes are purchased monthly by riders and permit unlimited travel on certain facilities throughout the month. Passes good on single

EFFECTS OF ALTERNATE FARE STRUCTURES

SUMMARY TABLE

Fare Structure Alternative	Change In Annual Ridership (millions)	Change In Annual Revenue (millions)	Change In VMT (millions)	Hydro-Carbon Emissions (tons/year)	Cost of Implementation	Ease Of Implementation	Political Feasibility
Low fares downtown	+	-	Negligible	Negligible	-	-	+
Self-Service	+	?	-	-	-	-	-
Free off-peak elderly	+6.7	-1.3	-7.2	-15.1	?	+	+
Full-price students	-2.5	+4.0	+3.4	+ 7.1	+	+	-
Half-fare for low-income	+1.3	-4.1	-3.5	- 7.4	-	-	?
Peak period surcharge	-<2	+6.5 to 7.8	+6.2	+13.0	+	+	+
Free rail-to-bus transfers	+2.0	-8.0	-6.2	-13.0	-	+	+
Free bus-to-bus transfers	+1.0	-2.9	-3.1	- 6.5	+	+	+

Source: C.T.P.S.

EFFECTS OF ALTERNATE FARE STRUCTURES

TABLE 5-2

vehicles are based on the cost of 18 roundtrips; passes good on two types of vehicles (e.g., bus and rapid transit) are based on the cost of 16 roundtrips made using both types each way.

Although passes technically are valid for only one rider's use, there is no control over the "lending" of one's pass to other riders. Recently, the MBTA has changed its passes so they can be read electronically at turnstiles in rapid transit stations.

A fully automated, electronic fare collection system would allow for a more diversified fare structure. Manual fare collection systems require that fares be either flat rates for all riders, or vary by only a few zonal boundaries. With a fully-automated fare system, fares could be designed on more specific mileage-based formulas. These would more accurately reflect the cost associated with the distance traveled as well as the cost associated with a particular mode.

5.4.1 Electronic Fare Collection

Electronic fare systems are in operation in Washington, D.C. (WMATA) and San Francisco, CA (BART). The nature of the systems permits fares to be set by time-of-day and distance between stations. Tickets purchased at vending machines in the rapid transit stations or at banks are required to enter and exit the system. In this manner, the fare is adjusted between the entry station, which, along with the time, is encoded on the ticket, and the exit station. These systems, however, have experienced several problems associated with equipment failure. To date, these systems have been implemented on transit lines having off-vehicle payment. Electronic fare collection systems would be difficult to institute on buses, where zonal systems are also the most difficult to initiate.

A fully automated system of the type described above would be expensive to implement on the MBTA. Ticket sales equipment and adjustments to turnstiles would be necessary. Instead, the MBTA is investigating enhancements to their prepaid pass electronic card system. This system is described in Section 7.1.2 in connection with productivity measurement programs.

5.4.2 Bulk Sale of Tokens

Another alternative which may be beneficial to riders and to the MBTA is bulk sale of tokens. MOlst prepayment plans including bulk sale of tokens offer a discount to buyers. According to a 1976 UMTA report, this is done for a variety of reasons including:

(1) Social policy, which dictates that some riders deserve lower fares,

(2) a general belief that discounts are appropriate for bulk sales because of the lower handling costs,

(3) a marketing judgment that the discount for and convenience of prepayment will encourage reluctant riders and additional trips by current users.

According to this report, the marketing reason was the most common reason among transit authorities surveyed for implementing bulk sale of tokens/tickets with a discount. There were savings reported by 20 of 32 authorities due to reduced coin handling and a small benefit to the authority's cash flow in cases where riders purchased tokens in bulk. An additional smaller amount of cash value was received by transit authorities through the loss, by riders, of tokens/tickets resulting in rides paid for but never taken.

Several transit authorities have recorded increases in ridership and efficiency where bulk token sales or similar programs have been implemented. In Stockholm, winter-season ticket holders (a bulk-type pass ticket) climbed in one year from 135,000 to 400,000. Season-tickets riders climbed from one-third of all riders to 70 percent in a year. Of course, there was a decrease in single-fare riders, but overall, ridership climbed 5 percent.*

In conclusion, bulk sale of tokens with discounts would appear to be convenient and advantageous for both riders and transit authorities. Riders pay less to travel and wait in line less; stations are less congested at token booths, and transit authorities can expect to maintain or increase revenue with marginal additional ridership.**

5.4.3 Self-Service Fare Collection

The basis for self-service fare collection is that each passenger is generally responsible for determining and paying his own fare. Riders are then subject to a fine or other sanction if proof of payment cannot be produced for an inspector. Self-service systems are fairly common in European cities but have been implemented only on a very limited basis in the United States.

A two-step process consisting of ticket purchase and later ticket verification is usually employed in self-service systems. The two steps are separated to permit multiple ticket purchases. Tickets may be sold by machine (accompanied by high capital cost, vandalism, and little revenue security) or by ticket agents or concessionaires (with high labor costs). Most systems sell tickets that act as receipts when verified at time of use. Inspectors are assigned to vehicles with the aim of checking each regular passenger on a certain percentage of bus trips (e.g., every twenty trips). Fines are then designed to recapture all lost fares assuming that the delinquent rider has not paid the fare since the last inspection; if inspections occurred every twenty trips, the fine would be twenty times the fare.

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*Michael Kemp, Reduced Fare and Fare-Free in Urban Transit Services, Urban Institute Paper, July 1974, p. 33.

**Transit Fare Prepayment, UMTA, DOT, August 1976, p. 65.

Several possibilities exist for ticketing and ticket validation procedures. The three most frequently adopted configurations are:

- issue and validate at stops only
- issue at stops, validate on vehicle
- validate on vehicle, no ticket issued

All of these options offer barrier-free access to vehicles leading to decreased dwell time at stations and stops. Turnstiles can be abandoned at subway stations (or used for counting riders only) and "all doors" access can be provided on buses and streetcars.

The potential increases in productivity resulting from these changes are one of the major benefits of self-service systems. Most European properties reported approximately a 10 percent service productivity improvement based on self service.* A second major benefit seen by the European operators was the increased feasibility of diversified fare structures aimed at various market segments and geographic areas. When the responsibility for computing and verifying fares was removed from vehicle drivers, more innovative and complicated fare structures became possible. Other benefits realized by self-service systems include lower fare collection costs in subways where extensive fare collection equipment is no longer needed, and improved passenger statistics provided by ticket verification machines recording time and location of trips.

It appears that European properties have had a generally positive experience with self service fare collection. The feasibility of implementing such systems in the United States, and perhaps particularly in Boston, poses unique problems. Problems surrounding implementation in Boston can be divided into two groups, those dealing with purchasing and maintaining automated equipment and those involving enforcement of fare and fine payment.

The high capital costs of automated ticket purchasing and ticket verification present a large, but probably surmountable, obstacle. Judging from other systems, the pressing problem would be the maintenance and protection of the machines. Ticket validation machines are especially sensitive, and machine malfunctions can be caused by routine occurrences like wet or damp tickets and vehicle vibration, as well as by intentional vandalism.

Enforcement of fare payment is also anticipated to be a problem. The riding public would have to take the ticket inspectors seriously. The transit system in Geneva was forced to double its fines in order to pay the city police to administer the fine collection system. Such a partnership would probably be necessary in Boston as well. Writing tickets to individuals requires that some form of identification is available. Furthermore, in a city where in 1980 as few as 20 percent of all fines for parking violations were paid, the transit system may have difficulty collecting enough revenue to support the administration of a self-service system.

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*Self- Service Fare Collection, Volume 1, Review and Summary, Mitre Corporation for U.S. DOT, August, 1979.

Self-service fare collection is generally credited with increasing transit ridership through improved service performance. Decreased dwell times on surface vehicles shorten travel times and enhance the potential for decreased headways. Lowered costs due to improved productivity can be passed along to the passenger in the form of decreased fares or slower increases in fares. As ridership increases, revenue from transportation increases as well. The enormous cost of enforcing fare payments in Boston may overshadow other savings, however, leaving the system no better off than it was previously.

These facts highlight the reasons why a system that is feasible in many European and Canadian cities may not work here. The single, well-publicized instance of a successful self-service system in the United States is in San Diego. The San Diego trolley, however, is a special case experience that may not be transferable to Boston for a number of reasons. The Metropolitan Transit Development Board (MTDB) was created in 1975 expressly to develop and maintain the trolley service, independent of the five other operators in the region carrying 28 million passengers annually. As it was, a new system, the implementation of self-service fares on the MTDB, was fairly straightforward and was simple to monitor. Furthermore, the decision to implement such a system in San Diego was made before the system was built and, therefore, reduced construction costs considerably. MTDB officials estimate that losses due to increased fare evasion will be more than offset by savings in construction costs. The eleven stations on the line do not need to be enclosed because they are not used to prevent unauthorized access to the trolley. The promise of reduced construction costs obviously holds little interest for Boston whose basic system has long since been constructed. It appears, therefore, that although self-service fare collection systems have been successful abroad and to a limited extent in the United States, their feasibility in Boston is of questionable benefit.

5.4.4 Impacts of Alternative Fare Collection Systems

The impacts of alternative fare collection systems have not been quantified. It is assumed that improved collection techniques might reduce dwell time, thereby reducing the total trip time. The impact on ridership, VMT, and the environment from this alone is assumed to be negligible. However, if these methods significantly change the level of service provided or offer savings either directly or secondarily through systemwide cost reduction, impacts would be measurable. Furthermore, the benefits of a system such as a fully automated system could become significant because of the ability to set fares more equitably.

5.5 LEGISLATIVE PROGRAMS

Some measures which would lessen the impact due to fare increases and service cuts of the sort implemented in 1981 are outside the direct control of the MBTA. Since both fare and service changes are required because of financial problems, additional funding sources in conjunction with improved operations are the key to the solution. Changes to the funding structure could not be implemented solely by the MBTA but would require state legislative action. Potential programs include state or local takeover of MBTA-sponsored subsidy programs, alternative funding through sales or gasoline taxes, or fare levels tied to inflation. These programs have been outlined below.

5.5.1 Subsidy Programs

As explained in Section 6, the MBTA currently subsidizes transportation for several groups of people: elderly, handicapped, students. The MBTA has requested that, as part of this study, the impacts of these subsidies on revenue be estimated and alternative mechanisms for subsidizing be addressed.

The cost of subsidizing the elderly has been estimated to be $12.0 million per year based on the current fare structure. The MBTA has suggested that the Human Services Division of the state or the Department of Elder Affairs pick up the cost of subsidizing travel by the elderly. The state could buy either tokens or passes at full face value and in turn either sell them at reduced rates to qualifying individuals or give them away. In this manner, the MBTA would receive the full value for the service provided. This type of program could also permit low-income individuals to be subsidized in a similar manner. If the Human Services Division set eligibility requirements for low-income riders, the tokens or passes could be distributed at reduced rates to qualifying individuals. A mechanism to prevent abuse of the reduced rates would have to be set up by the administering agency.

Similarly, school departments are subsidized by the MBTA for transporting students to school. The loss in revenue for school trips totals $2.8 million per year. If the MBTA sold student badges to school departments for an amount equal to the fares paid by students over the course of a year (i.e., half fare X the number of school days X two trips per day), the MBTA would recoup the money spent on subsidizing student trips.

5.5.2 Alternative Funding Sources

The present funding sources of the MBTA, which have already been identified in Section 2.7, include the federal, state, and local governments and the MBTA passengers. As the federal government operating subsidy is being phased out and local government finances are being restricted by Proposition 2½, alternative sources of funding are being sought. The state's share comes primarily from the general tax fund and gasoline taxes; the local share comes from the property taxes. The equity associated with these alternative tax sources has been addressed in Section 6.0

Additional possible sources of revenue include the following taxes: sales, gasoline, payroll, employer, parking, auto excise, and other excise taxes. Evaluations of these methods have been conducted in various studies with regard to criteria such as: yield potential, economic benefits, equity, political acceptability, and administrative difficulty. An investigation of taxes shows that some are strong in some areas, but weak in others. One with a high potential yield may be politically unacceptable; one which features an equitable share of burden for all economic groups may be impossible to administer, etc. A short discussion of several alternative revenue sources follows:

A. Sales Tax

The sales tax is the most popular tax for transit nationally, with 9 of the country's 26 largest metropolitan areas using it to complement their federal subsidies. It has a high potential yield and will keep pace with inflation. A one percent increase in the tax would bring in $75 million annually to the MBTA district.* Opinions differ as to whether sales taxes are regressive. Palmere** says they're fair, but others including UMTA say "sales and excise taxes are much more regressive than any other major family of taxes." Yet public opinion polls, according to UMTA, show that retail sales taxes are popular as means of additional revenue.***

In Atlanta, a one percent sales tax and use tax was levied in two counties to allow fare reduction. Sales tax and fare revenue were applied to meet development and operating costs. The immediate result was a 30 percent increase in ridership. A survey in November of 1972, 10 months after the decrease in fares, showed 91 percent of the increase was due to new riders and 41.8 percent of the new riders previously made the same trip by automobile.**** The Atlanta study also reported the sales tax was regressive, but pointed out that consideration had not yet been given to the "compensating effect" of the low fare.

The problem with a sales tax, in addition to its alleged regressivity is that it may decrease sales in a region and cause shoppers to go beyond borders to bury certain things. The sales tax, also, is not directly tied to the transit problem as is, say, a tax on parking or gasoline.

B. Gas Tax and Auto Use Charges

Gas tax and auto use charges were a prominent proposal of the Governor's Task Force on the MBTA. It also has the support of the Carmen's Union. It would conceivably cause a reduction in auto use, and improve air quality and reduce energy consumption. The poor would pay less and the middle class more, but people could control their costs by driving less or carpooling. As a revenue source, it would be a reliable one with as much as $10 million annually in the district. Five metropolitan transit systems currently gas taxes.

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*Anthony J. Palmere, Alternatives for Financing the MBTA, (unpublished thesis), Kennedy School of Government, Harvard University, 1981.

**UMTA, Department of Transporatation, Financing Transit, Alternatives for Local Government, July, 1979.

***John W. Bates, "Using Sales Tax to Support Low Fare Pricing of Transit Services in Atlanta" in Urban Transportation

****William C. Nevel, "Case Studies on Increasing Transit Revenues: Northeastern Illinois," Urban Transportation Economics.

An UMTA report, however, takes the slightly different view that only a large increase in the gas tax would have an effect on travel and travel patterns because of the low elasticity of demand for fuel and travel. Automobiles, the report claims, are and will still be used for trips for which there is no transit alternative.

Parking taxes are a form of auto use charge that according to one study would yield a "modest, but significant amount of revenue". There has been resistance, however, on the part of parking lot operators, particularly in San Francisco, to these programs. The objections are principally that these taxes:

(1) Discriminate against drivers who are obliged to use commercial parking facilities.

(2) Place a financial burden on the parking industry.

(3) Had little effect (in the San Francisco case) on traffic coming into the city because only about 20 percent of the incoming vehicles used commercial parking facilities.

There is little information on the effects of parking taxes on different income groups.

Bridge and tunnel tolls would seem to be directly related to reducing traffic congestion but only 3 cities--New York, Philadelphia, and San Francisco--use them to partly finance transit. There are implementation problems including legal obstacles related to how the revenue from tolls can be spent. Generally, it is directed only to the maintenance and reduction of capital debt of the tolled facility.

C. Payroll Taxes

Payroll taxes are imposed on employees or the employer. It may be assumed that they are passed on to employees. If paid by the employer, the tax could be deducted as a business expense. Generally, under these proposals, small firms are not taxed, but this means that doctors, lawyers, and other self-employed people may not be taxed at all. Small companies and those located outside the district would gain, some would say, an unfair advantage. Other companies making a location decision may elect to locate outside the district. The greatest objection to these taxes is that they are already used heavily for retirement, social security, and workmen's compensation.

The potential yield is high from payroll taxes for a small percentage tax. As with the gas and sales tax, it is tied to inflation. The estimated revenue gain for the district is $72 million annually with only a one half percent increase.

Other revenue sources considered by transit authorities have included: joint development of air rights over public property or leasing and/or sale of supplemental property; taxes on so-called "harmful" products such as liquor or tobacco (Massachusetts used to collect 2 cents per cigarette pack for transit funding); increases in the personal income tax (this has been considered by some transit agencies but is generally considered politically unacceptable). Finally, the City of Chicago considered a lottery (it was not legal at the time) to raise $60 million/year with one-half going to mass transit.

5.5.3 Cost-of-Living Indexing

One proposal being set forth by the MBTA would provide the MBTA with periodic fare hikes based on inflation. As the costs to the MBTA of providing service increase due to factors outside the control of the "T", such as increased fuel costs, the fares would be increased to compensate for these costs. A system of this type could be tied to the Consumer Price Index (CPI), the Producer Price Index (PPI), or, since the MBTA is an energy-intensive operation, a motor fuel price index. Adjustments could be made to the fares either annually or, more likely, biennially. Further refinement would be necesary to ensure a rounded fare level (e.g., to the closest 5 cents).

Fare changes tied to these indices would be most significant during times of inflation. For example, if inflation were 10 percent over the time period measured, fares would increase by 10 percent. Tables presented in Section 2 have pointed to the disparity between real costr and real fares over time; fares have not kept up with inflation. As an example of the cost of living indexing proposal, it was assumed that inflation over the next two years is 10 percent per year. This translates into an increase in fares of 21 percent to roughly 60 cents on the bus and 90 cents on rapid transit. If fares were adjusted annually, the fares after one year would be 55 cents and 85 cents.

It is expected that small adjustments to fares each year would not have as dramatic an impact on ridership, especially if they are tied to the cost of living index. Regardless, some riders would divert to other modes.

5.5.4 Recommendations of Other Studies

The UMTA report Financing Transit does not recommend a clear-cut alternative revenue-source because of the various kinds of inequities each tax incurs. What they do recommend is "greater financial and operating efficiency" and responsible financial management.

Accounting and management data are, or should be, brought together in the operating budget which, as the operating plan, should be a principal tool for decision-making by transit agency managers and boards of directors. Moreover, now that a large and growing proportion of transit operating costs are paid for by tax revenues, rather than fares, local and state elected officials and legislators will increasingly demand to know what they are getting for their subsidy funds, in terms of concrete services. A financial plan, therefore, must require not only the analyses to provide such information, but also that the information be intelligible and persuasive, if transit is to hold its own in competition with other public services.

The system proposed for Chicago's Regional Transit Authority included revenue from the sales tax, a $14 excise tax for vehicle registration, a 5 percent sales tax on motor fuel, and an all-day (commuter) parking tax. Thus, some areas are experimenting with combinations of taxes.

Anthony J. Palmere's Alternatives for Financing the MBTA makes recommendations for the short-run, while developing some long-range goals for the MBTA. In the short-run, Palmere suggests a gas tax combined with an increase in fares "to let people know that transit will only receive limited public financial support in the future." Under this proposal, gas prices and fares would rise together so that neither would have an unfair advantage. Palmere suggests a sales tax as a second alternative to assist local communities in coming up with their share of MBTA funding.

The long-range goals developed by Palmere e cho the comments of the UMTA report--the MBTA must be run more efficiently. If possible, some system of incentives should be provided to increase efficiency. Palmere also recommends a user subsidy for low-income riders since the MBTA will be depending on operating revenues.

One point on which many of the studies could agree was raised by Ralph E. Rechel and others: ". . . a funding source is needed that will expand with inflation. A perpetual problem exists if this basic need is inadequately addressed."

6.0 SOCIOECONOMIC IMPACTS

The purpose of this section is to identify and describe the impacts of recent fare increases and service cuts on various broad socioeconomic groups. First, the social benefit of public transportation is discussed in terms of both direct user and indirect non-user benefits. Next, a description of the impacts of fare increases and resultant reduction of trip-making is provided by user type and socioeconomic group, where possible. The losses in trips made by the elderly, the handicapped, youth, and low-income users are estimated. In particular, changes in the number of discretionary trips and shopping trips are noted.

Several categories of users have been identified as being more negatively affected by the fare increase. Some measures that may be taken to mitigate the impacts of the fare increases on these users have been outlined, and the MBTA's existing subsidy programs are described.

6.1 SOCIAL AND ECONOMIC VALUE OF PUBLIC TRANSPORTATION

A basic goal of public transportation is to provide mobility and equality of access to employment, health care, educational, cultural, and shopping opportunities. It strives to provide efficient transport of people in and through urban areas. Furthermore, public transportation enhances the broad goals of promoting social and economic equity for residents of urban areas, as well as increasing employment and employment opportunities, revitalizing the economic base of central cities, and improving the quality of life in an urban environment.

The socioeconomic value of public transportation can be discussed in terms of direct and indirect benefits to users and non-users and is realized at both the individual and community, as well as on a regionwide level. The social and economic impacts of public transportation can most easily be described in terms of captive and discretionary ridership.

Captive Ridership

Captive riders are generally from autoless households and are dependent upon public transportation for access to employment and essential services. Although the majority of Americans depend on the automobile as their primary mode of transportation, significant populations of the poor, the elderly, and the handicapped in urban areas cannot affort or are physically unable to operate an automobile. The majority of autoless households generally reside in urban core areas, tend to have lower incomes and are often elderly. It is for this segment of the metropolitan population that public transit is critical to the quality of life. These population groups constitute the majority of captive riders on transit systems.

Low-Income Riders -- Public transportation has particular value to the low-income captive rider. Public transit increases his job opportunities by providing transportation to employers. A 1978 Ridership Survey conducted by the MBTA revealed that the majority of transit trips made by the low-income captive rider were work trips. The direct benefit to the low-income captive rider and his employer is realized as an indirect benefit to society in the form of increased employment levels, greater economic productivity, and reduced dependence on public assistance.

Elderly and Handicapped Riders -- Elderly and handicapped residents of urban areas are often living on reduced or fixed incomes and unable to affort private transportation. The elderly and handicapped also have a greater incidence of physical disability which prevents them from operating an automobile, making them dependent on public transportation for access to employers and essential services. It, therefore, provides an essential social service to the elderly and handicapped. In terms of future transportation policy, it is important to note that persons over 65 years of age will represent an increasingly large percentage of the general population.

Discretionary Riders

Discretionary riders are defined as those persons who have access to an automobile and, therefore, have a choice whether to use public transportation. Public transit supplies benefits to these riders by providing them with an alternative mode of transportation for work and other trips. The 1978 MBTA Ridership Survey revealed that discretionary riders use the transit system primarily for commuting trips.

Reduced travel time and costs are major reasons for the diversion of discretionary riders to mass transit. The most significant time savings are realized on rail facilities having exclusive rights-of-way. Cost savings are realized through reduced automobile operation and maintenance expenses, eliminated parking fees, and reduced insurance premiums. Another benefit accrues from public transportation being a safer mode of travel than the automobile, which reduces the likelihood of personal injury. This is particularly the case during adverse weather conditions, when transit may provide not only a safer, but a more reliable form of transportation. Data indicates that ridership levels increase during inclement weather.

Non-User Benefits

Public transportation also provides indirect benefits to the automobile commuter, urban resident and retail and commercial establishments. As persons divert to transit, a reduction in automobile use occurs, which reduces congestion, potential accidents and fatalities, and improves travel times for other motorists. These impacts are most evident during peak travel periods. Although such benefits may not be obvious to the urban motorists, the positive impact of mass transit systems on the operation of roadway systems becomes readily apparent when the transit system shuts down. Indirect public health benefits also accrue from the reduced traffic congestion and improved traffic flow in the form of reduced auto emissions, a major source of urban air pollution.

As stated previously, public transit has a positive impact on employment to the extent it increases job opportunities for the captive rider and links labor with potential employers. Transit authorities also act as major employers, creating jobs for the development, construction and operation of the transit system. In 1980, the MBTA employed 6,748 persons, with a total annual payroll of $140.5 million.* Transit authorities also provide jobs for architectural, engineering and other consultants. Employment directly or indirectly attributable to public transportation stimulates the economy by increasing disposable personal income, leading to greater consumption of goods and services. Greater consumption of goods and services can in turn stimulate industries and create additional jobs.

Public transportation has the positive impact of increasing land values near access points to the system; attracting desirable residential, commercial and retail land uses; and increasing local tax bases. This dynamic is most readily apparent in new extensions such as the extension of the Red Line to the South Shore.

It also enhances business in downtown shopping centers by increasing their effective service area. Auto travel to urban shopping centers is typically associated with traffic congestion and high parking fees, especially when compared with the suburban shopping mall. The success of downtown shopping areas served by public transit is well documented in Boston and other U.S. cities Attendance at sporting and cultural events, and other downtown recreational activities is also increased.

In summary, public transportation provides both user benefits in the form of increased accessibility to employment, shopping, and cultural opportunities, and non-user benefits such as decreased traffic congestion, increased land values, and increased labor markets.

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*MBTA 1980 Annual Report.

6.2 CHANGES IN RIDERSHIP LEVELS FOR SOCIOECONOMIC CATEGORIES OF USERS

Several groups of users who appear to be more sensitive to a fare increase have been identified in Section 6.1. These include low-income persons, students, elderly, youths, and handicapped persons. In addition, persons making discretionary trips (shoppers, tourists) and non-captive commuters (those having an automobile available) are more likely to change their trip-making behavior due to a fare increase or service change. An attempt has been made to identify the number of trips made by each of these groups of users before the recent fare increases and determine the magnitude of the change in trips following the changes in fares and service levels.

The base information was obtained from the 1978 Systemwide MBTA Survey, adjusted to reflect 1979 ridership levels. The 1981 level was derived either from the fare mix sampling program of November 1981, or through the application of disaggregate elasticities to the 1979 levels. The results of this analysis are presented below by type of user.

It should be noted that, although the handicapped have been identified as a group that benefits from public transportation and in some cases is dependent upon it, the impacts on this group of users is not addressed separately. Instead, those handicapped persons using the MBTA's regularly scheduled service have been grouped with the elderly. This was done for a few basic reasons. First, the 1978 Systemwide Survey, which serves as a base for these socioeconomic groupings, did not have a statistically significant number of responses from handicapped riders. Detailed breakdown of their trip-making behavior was not, therefore, possible. Second, the MBTA provides a demand-responsive system for handicapped persons called The Ride, which was not affected by these fare increases. Third, the fare changes seen by the handicapped were the same as those facing the elderly and, therefore, permitted combining the two groups. In addition, the 1981 ridership sampling program grouped the two categories of users in their breakdown of fare payment.

6.2.1 Income

Low-income persons are generally more dependent upon public transportation for their travel needs than are persons in the middle-income or upper-income groups. According to the 1977-1978 National Personal Transportation Study (NPTS) conducted by the Census Bureau for FHWA, approximately one-third of the bus or streetcar users in cities with populations between 500,000 and one million people had low incomes (less than $6,000/household). In contrast, only 11 percent of the automobile drivers were in this income group. In general, low-income groups make up a larger portion of the streetcar or bus riders (28.3 percent) in all metropolitan areas than they do of the rapid rail (16.2 percent) or commuter rail riders (9.3 percent).*

The 1978 MBTA Systemwide Survey provided information on the household income of MBTA riders. Overall, 23 percent of the total riders had household incomes less than $8,000 in 1978. The survey might have underestimated the proportion of low-income riders because the sensitivity of this type of question results in many "no answers". For this analysis, the 1978 income levels have been increased to 1979 and 1981 dollars by using the change in personal income for the state over this time period.**

The number of trips made by low-income persons on an average weekday are as follows:

	1979		1981		Change	
	No.	% of Mode	No.	% of Mode	No.	% of Mode
rapid transit only	37,100	(20.3%)	27,600	(20.5%)	- 9,500	(-25.6%)
combination rapid transit and surface	54,200	(21.5%)	43,600	(22.4%)	-10,600	(-19.6%)
surface only	56,900	(29.2%)	49,300	(27.7%)	- 7,600	(-13.4%)
TOTAL	148,200	(22.8%)	120,500	(23.7%)	-27,700	(-16.1%)

Both the fewest number of trips and the smallest proportion of trips made by low-income riders are on the rapid transit system. As expected, the greatest proportion of low income riders made bus trips.

The loss in trips was estimated by adjusting the modal elasticities by a disaggregate fare adjustment factor of 0.72** and applying it to the change in average fare by mode. The factor is less than 1.0, indicating that the responsiveness of low-income riders to changes in fares is generally lower than that of the entire population. Low-income riders generally have fewer alternatives to transit, owning fewer automobiles per household and having a lower likelihood of an auto available for a particular trip.*** Although fewer low-income persons are riding the MBTA now than they were in 1979, a greater proportion of the system's riders are from low-income households. In addition, a greater proportion of their total household income must be devoted to riding the MBTA. The issue of fare burden per household is addressed in a subsequent Section 6.4 of this report.

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*The numbers referred to the NPTS were reported in "Equity in Transit Finance," John Pucher, Journal of the American Planning Association, Volume 47, Number 4, October 1981.

**Ecosometrics.

6.2.2 Age

The age of individual riders is also of interest in determining the response to changes in fares. Two age groups are of particular importance in an analysis of the socioeconomic impacts of a fare increase--the young and the elderly. The effects of the fare increases over the last two years on each of these two age groups are described below.

The Young

The fares paid by this group of riders depend on age and trip purpose. Children under five years of age ride free at all times; those between five and eleven years pay half fare at all times. No identification card is provided to prove one's age, and so it is up to the discretion of the bus driver or token collector to determine the eligibility of a particular rider. In addition, children between 12 and 18 years making a school trip are permitted to pay half fare provided they show an eligibility badge. The badges are distributed through the local public and private school departments at no charge. Prior to July 1980, students were allowed free transfers.

Since 1979, trips made by children (5 to 11) and students dropped by approximately 28 percent. In all, 17,000 fewer MBTA trips were made by this group on an average weekday in 1981 as compared with 1979. It is important to determine which types of trips are no longer made and which ones are now made using another mode. It is a fair assumption that school trips are still made--students either walk, bicycle, or are driven go school by their parents. It should be noted that some school departments (e.g., Boston) are now subsidizing students who ride the MBTA to school by purchasing tokens or passes from the MBTA and providing them to qualifying students. Approximately three-quarters of the trips made by students and children appear to be school trips; one-fourth are, therefore, non-school trips.

In 1979, non-school related youth trips amounted to 15,000 trips per average weekday. In 1981, it is estimated that the number of trips of that type has dropped to 10,600 trips per day. The largest decline was estimated to be from rapid transit. It is

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***1978 Systemwide Survey data.

impossible to ascertain whether these trips are no longer made or are diverted to some other mode, e.g., walking, bicycling, or being driven. A mix of these possibilities is most likely.

Whereas in 1979, trips made by students and children constituted almost 10 percent of total system trips, in 1981, they comprised slightly less than 9 percent. The proportion of non-school related trips made by youths had dropped from 2.4 percent of total trips to 2.1 percent in 1981.

	1979* (No. Trips/ Avg. Weekday)	1981** (No. Trips/ Avg. Weekday)
Total Students and Children (5+) Trips		
rapid transit only	10,400	6,600
combination	29,000	18,800
surface only	21,900	19,000
TOTAL	61,300	44,400
Youth--Non-School Related Trips		
rapid transit only	6,500	4,100
combination	4,400	2,900
surface only	4,100	3,600
TOTAL	15,000	10,600

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*From 1978 MBTA Systemwide Survey.

**Derived from elasticities for non-school related trips; observed in November 1981 sampling program for total student/youth trips.

Elderly

As described in the introduction to this section, the provision of public transportation to the elderly produces significant user benefits as well as substantial indirect benefits to society. Due to the sensitivity of this group of riders to higher fares, the MBTA provides free access for the elderly to the entire system between 9:30 AM and 4:00 PM, Monday through Friday. Prior to August 1981, the elderly paid half the full adult cash fare based on fare levels charged prior to the 1980 fare increase. After August 1981, the fare structure required that the elderly pay half the current full adult cash fare except during the free-fare time period. For those riders who do not take advantage of the free fare time period, fares increased by between roughly 100 and 200 percent, depending upon the mode used. A similar fare structure is provided to handicapped riders; this discussion, therefore, includes both groups of riders.

Since the institution of free fares, elderly and handicapped ridership increased by approximately 13,000 riders per average weekday. Approximately 20,000 additional senior citizen identification cards were distributed by the MBTA in the last half of 1981 after the free fare was implemented. This group comprises over 12 percent of current average weekday ridership. This compares with almost 8 percent in 1979. Some ridership figures for the elderly and handicapped are presented below.

It was assumed that no work trips were lost from this category because of the relatively small absolute increase in fares seen by this group for a work trip. In order to avoid payment of the increased fares, it is expected that the elderly would switch the time of their trip for most discretionary trips rather than not ride the MBTA. As can be seen from the data below, it is expected that an increase of 35 percent of non-work trips has resulted since the fare change in 1981.

Total Elderly and Handicapped Trips

	1979* (No. Trips/ Avg. Weekday)	1981** (No. Trips/ Avg. Weekday)
rapid transit only	14,300	16,900
combination	23,400	27,400
surface only	11,300	18,000
TOTAL - half fare	49,000	22,000
- free	--	40,300

Elderly and Handicapped Non-Work Related Trips

	1979*	1981**
rapid transit only	9,900	12,500
combination	18,500	22,500
surface only	9,300	16,000
TOTAL	37,700	51,000

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*Derived from 1978 Systemwide Survey.

**Derived from 1981 Sampling Program and 1978 Survey distribution of trip purposes.

6.2.3 Trip Purpose

Trip purpose has also been used to group responses to fare and service changes. Two groupings are of particular importance in this analysis: discretionary trips and work trips. They are described in the next few paragraphs.

Discretionary Trips

In general, discretionary trips are more sensitive to changes in fares and service levels than are work or school trips. In this analysis, discretionary trips include shopping, social, recreation, tourist, and other trips. The last three types have been grouped as other because of a lack of specific data. Work, school and medical trips were considered to be non-discretionary trips. In general, the rider has more of an opportunity to change the destination or mode of a discretionary trip than of a work or a school trip.

The number of discretionary trips by mode are shown in Table 6-1 for 1979 and 1981 to represent pre- and post-fare increase levels. The losses in trips shown in the table were estimated by applying an elasticity adjustment factor of 1.13 to the modal elasticities derived in Section 3, and the proportional change in the average fare over this time period.

Overall, 22 percent of the trips made in 1979 were discretionary trips; most were made on the rapid transit system. The fare increases and service changes between 1979 and 1981 have caused the number of discretionary trips to drop from an estimated 138,700 trips per average weekday to about 105,000 trips or roughly 19 percent of the total trips. This is equivalent to a drop of one-third. The greatest loss was in the number of discretionary trips made on the rapid transit system. The smallest loss was on the surface vehicles.

Of the 43,000 discretionary trips no longer made on the MBTA, approximately 12,000 are trips that are no longer made at all (see Appendix F for a discussion of the diversions of trips to other modes). A large portion of the remaining lost trips are probably made by driving or walking to other destinations. The number of shopping trips made on the MBTA decreased by 16,700 between 1979 and 1981. The impact of this is described in Section 6.3 for each type of rider.

Work Trips

Work trips are the least sensitive to changes in fares. In general, the average income of persons making work trips is higher than that of the overall riding population. This group is also most likely to own automobiles and can, therefore, divert to driving instead of taking transit to work if the fares become too high, or service levels too low. The riders making work trips

	Rapid Transit	Combi-nation	Surface	Total
1979				
Shopping	16,900	18,800	18,900	54,600
Social	15,900	9,600	7,600	33,100
Other	18,000	17,500	15,500	51,000
TOTAL Discretionary	50,800	45,900	42,000	138,700
% of Mode's Trips	27.9%	18.2%	21.5%	22.1%
1981				
Shopping	10,100	12,900	14,900	37,900
Social	9,500	6,600	6,000	12,100
Other	10,700	12,000	12,300	55,000
TOTAL Discretionary	30,300	31,500	33,200	105,000
% of Mode's Trips	22.6%	16.2%	18.7%	18.7%
% Change	-40.5%	-31.3%	-20.9%	-24.3%

Source: 1979 distribution derived from 1978 MBTA Systemwide Survey; 1981 figures derived by applying elasticities to the 1979 categories.

DISCRETIONARY TRIPS PER AVERAGE WEEKDAY (1979 AND 1981)

TABLE 6-1

were grouped into captive riders--those without an automobile, and discretionary riders--those having access to an automobile. The ridership levels are shown in Table 6-2 for 1979 and 1981. The figures for 1979 were derived form the 1978 Systemwide Survey. The 1981 levels were estimated using elasticity adjustment factors for work trips (0.69), modified for choice (1.31), or captive (0.63) riders. The proportional change in fare used was that associated with full-fare adult or prepaid pass users.

The total loss in work trips was estimated at approximately 77,400 trips per average weekday. This represents a 27.5 percent loss in total work trips. As expected, the greatest loss (58,400) was for discretionary riders; captive riders showed a smaller absolute (19,000 trips) and proportional change (-21 percent). In general, persons making work trips divert to other modes as opposed to foregoing the trip or changing work location. The latter alternative might be a long-term implication of generally rising transit fares, but is offset by changes in automobile commuting costs.

6.3 IMPACTS OF RETAIL TRADE

This section describes the impacts of the fare increase on retail trade and presents data on the number of lost shopping trips. Retail shopping trips made in 1979 and 1981 are delineated by fare type and transit mode in Table 6-3. The data presented in the table indicates a decline of 16,630 shopping trips from 1979 to 1981, or 30.5 percent of the 1979 shopping trips made using the MBTA. It can therefore be broadly concluded that the fare increase significantly curtailed discretionary shopping trips among the transit riding public.

Lost shopping trips can result in lost sales and, thus, have a negative impact on retail trade. The positive relationship between public transportation and retail sales was clearly evidenced by the one-day MBTA shutdown in December 1980. Losses in sales as estimated by downtown retail merchants totaled $6,000,000. These sales, however, were probably made in suburban shopping centers accessed by automobile. The Boston Redevelopment Authority has estimated that shoppers spend an average of $15 per trip on the average weekday. It is estimated that 5,200 lost transit shopping trips (derived by applying the ratio of shopping-to-discretionary trips to the number of trips no longer made) were not recovered by other transportation modes. This results in $78,000 in lost retail sales for the average weekday, or $23.3 million in annual sales. It is expected that 11,500 of the 16,700 lost trips do not result in lost retail sales as the trips are still made either to other shopping centers or by other modes.

The data illustrates that ridership losses were restricted to students, children and adults paying full fares. The greatest loss in shopping trips was from those riders who pay full fare.

	Rapid Transit	Com-bination	Surface	Total
1979				
Discretionary*	50,000	88,200	51,000	189,200
Captive**	32,200	30,500	23,700	91,400
TOTAL Work Trips	82,200	118,700	74,700	280,600
1981				
Discretionary*	30,900	61,900	38,000	130,800
Captive**	25,700	26,000	20,700	72,400
TOTAL Work Trips	56,600	87,900	58,700	203,200
Percent Change	-31.1%	-25.9%	-21.4%	-27.6%

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*Automobile owner
**No automobile

Source: 1979 trips derived from 1978 MBTA Systemwide Survey; 1981 trips derived by applying elasticities to the 1979 figures.

WORK TRIPS PER AVERAGE WEEKDAY FOR DISCRETIONARY AND CAPTIVE RIDERS (1979 AND 1981)

TABLE 6-2

	Rapid Transit	Combination	Surface
1979			
Adult Full Fare	14,200	11,890	11,530
Prepaid Pass	1,000	940	920
Elderly & Handicapped	1,220	5,070	4,880
Students & Children	370	730	1,360
Other	100	140	220
TOTAL	16,890	18,770	18,910
1981			
Adult Full Fare	6,770	6,380	7,270
Prepaid Pass	1,000	940	920
Elderly & Handicapped	1,460	6,040	5,860
Students & Children	130	240	470
Other	100	140	220
TOTAL	9,460	13,740	14,740
Percent Change	-44.0%	-26.8%	-22.1%

SOURCE: 1979 distribution derived from 1978 MBTA Systemwide Survey; 1981 figures derived by applying elasticities to the 1979 categories.

SHOPPING TRIPS PER AVERAGE WEEKDAY BY FARE TYPE
(1979 AND 1981)

TABLE 6-3

The greatest percentage decline in shopping trips occurred within the student and children fare category, where ridership declined by almost two-thirds. This is attributable to the large percentage change in these fares between the two time periods. Shopping trips made by the elderly and the handicapped have probably increased as these groups now ride free between 9:30 AM and 4:00 PM. Trips made by prepaid passholders should not have changed due to the fare hike, since a shopping trip would not cost more if the pass is already bought for work trips.

Ridership loss was most pronounced among those who used rapid transit exclusively. Retail shopping trips on rapid transit declined by 44.0 percent. Losses in surface-only and combination trips were less severe, at 22.1 and 26.8 percent, respectively. This is explained in that full-fare shoppers constituted a higher percentage of rapid transit shoppers (84.0) than they did of surface only (61.0) or combination trips (63.3).

6.4 FARE BURDEN

In addition to looking at the absolute and percentage changes in ridership according to socioeconomic classifications, it is also relevant to determine the financial burden on each group associated with using the MBTA and relate that measure to the ability of each group to pay. The comparison of fares paid with cost of service for a particular mode is also of interest when addressing the socioeconomic impacts of fare policies. These issues are discussed in the remainder of this section.

In this analysis, the proportion of total household income that is spent on the MBTA is referred to as the "fare burden." It is not possible to directly determine the "fare burden per household" because recent information is not available on the MBTA usage rates per household. This analysis, therefore, derives a fare burden assuming one MBTA rider per household who makes a fixed number of trips. This enabled a comparison between different income groups and fare payments.

The proportion of household income devoted to MBTA fare payment is shown in Table 6-4 by income level and mode for 1979 and 1981. The annual fare payment per household for public transportation is also shown in Table 6-4 for the various fare payment categories (full adult fares, prepaid pass, elderly and student half fare, average system fare).

Overall, 1.6 percent of the average rider's household income was spent on the MBTA in 1981.* This compares with 1.2 percent in 1979. The figures show that riders from low-income households can devote as much as 6.5 percent of their income to using the MBTA if they use both rapid transit and surface vehicles for each trip;

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*Annual figures were computed based on the post-August 1981 fare structure.

		1979			1981	
Type of Payment	Rapid Transit	Comb- ination	Surface	Rapid Transit	Comb- ination	Surface
Full Fare*	$137.50	$304.00	$191.50	$387.50	$711.50	$372.50
Prepaid Pass*	113.00	222.00	122.00	320.00	526.50	246.00
Elderly-Half Fare*	57.50	135.50	89.50	194.00	356.00	185.50
Student**	41.40	44.50	47.50	140.00	256.00	134.00
Average Fare*	120.00	250.00	144.00	300.00	494.50	227.50
Mean Household Income(1) (Annual)	$18,400	$17,200	$15,600	$23,100	$21,600	$19,600
% of Income Spent on Average Fare	0.7%	1.5%	0.9%	1.3%	2.3%	1.2%
Average Low Household Income(1) (Annual)	$5,800	$6,000	$5,900	$7,300	$7,600	$7,400
% of Income Spent on Average Fare	2.1%	4.2%	2.4%	4.1%	6.5%	3.1%

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*Assumes 250 round trips/year.

**Based on 180 round trips/year.

(1) From 1978 Survey, adjusted by change in personal income from the Bureau of Labor Statistics; the income levels are probably overestimated, due to potential bias in survey for this question.

ANNUAL FARE PAYMENTS BY TYPE OF RIDER (1979 AND 1981)

TABLE 6-4

prior to the fare increases in 1980 and 1981, this figure was 4.2 percent. This implies that over 50 percent more of one's income must be spent on traveling on the surface and rapid transit lines. As much as 2.3 percent of the average user's income is spent on fare payment in 1981. This is up from 1.5 percent in 1979.

The fare increase has had a greater impact on the low-income user. Although the fare increase for both low- and high-income users had the same absolute dollar value, the percentage of income that a low-income household must spend on the MBTA is significantly greater than that of a higher income household. For instance, the fare paid over a year on rapid transit rose on average from $120/year to $300/year. The average-income household riding the MBTA must devote an additional 0.6 percent of his income to riding transit. The average low-income user must devote an additional 2.0 percent of his income to riding the transit system. The additional fare burden for the low-income rider is, therefore, approximately three times as great.

Data on the cost of operating each mode of public transportation is provided below for 1979.*

	Operating Cost (Millions)	Cost/Revenue (Vehicle) Mile
rapid transit	$106.4	$10.52
surface	106.1	3.77
- streetcar	16.4	3.19
- bus	85.8	3.86
- trolley bus	3.9	4.86
commuter rail	41.2	7.11

The data shows a large difference between the cost of operating each mile of rail service and each mile of bus service. Each vehicle mile of surface service is less expensive to operate, however, each vehicle mile of surface service also has the capacity to carry fewer passengers than a mile of rail service. Based on a national average trip length of 7.1 miles for rapid transit and 5.12 miles for surface trips, we can modify the annual operating costs by the number of passenger trips or passenger miles results in the following unit cost estimates.

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*At the time this analysis was conducted, 1979 data was the most recent available.

	Cost Per Passenger Mile	Cost Per (one-way) Passenger Trip
rapid transit	16.4 cents	$0.58
surface	16.2 cents	$0.42

The number of passenger miles traveled per year was derived through an estimate of the average length of a rapid transit or surface trip. Since recent data specific to the MBTA was not available, national data from NPTS was used. As can be seen from the figures below*, average trip length varies by mode and income of each user. In general, commuter rail trips cover longer distances than trips on other modes. Trip distance also increases with the income of the rider.

	Low Income (miles/trip)	Mean Income (miles/trip)	High Income (miles/trip)
rapid transit	6.3	7.1	8.5
combination**	8.0	9.2	12.5
surface	4.4	5.2	8.1
commuter rail	16.8	15.9	21.6
Average	5.0	6.8	11.4

**Derived by taking 75 percent of the sum of the average rapid transit and surface trip lengths.

In order to compare the fare the user pays with the cost of providing that service, values for the fare/mile, fare/trip, and cost/passenger-trip were derived by income group and mode. These are presented in Table 6-5 for 1981. Due to the longer trip lengths of higher-income riders, their fare per mile traveled on the MBTA is less than that paid by lower-income persons. The total cost associated with providing the trips to higher-income groups is greater, again due to the longer trip length. A detailed distance-based fare structure would alleviate some of the inequities associated with the broad zonal fare structure

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*SOURCE: 1977-1978 NPTS data in "Socioeconomic Characteristics of Transit Riders: Some Recent Evidence," J. Pucher, et al, Traffic Quarterly, Volume 35, Number 3, July 1981.

	Fare/Mile* 1981 (Cents)	Fare Per Passenger 1981 (Cents)	Operating Cost Per Passenger Trip** (Cents)
Low Income			
Rapid Transit	9.5	60.5	103.3
Combination	12.4	98.9	130.4
Surface	10.3	45.5	71.3
Mean Income			
Rapid Transit	8.5	60.0	116.4
Combination	10.8	98.9	150.0
Surface	8.8	45.5	84.2
High Income			
Rapid Transit	7.4	60.0	139.4
Combination	7.9	98.9	203.8
Surface	5.6	45.5	131.2

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*Uses average fare.
**1979 cost data.

SOURCE: 1981 data was derived from the results of the 1978 Systemwide Survey.

FARE PER MILE AND COST PER TRIP BY INCOME AND MODE

TABLE 6-5

currently used on the MBTA. It should be noted that the actual cost of providing service varies by rapid transit line and bus route, and to the time of day that service is bring provided. To derive the true marginal cost of carrying specific groups of riders, more detailed breakdowns of costs, which are currently unavailable, would be needed.

6.5 SUBSIDY PROGRAMS

As was demonstrated from the operating cost figures and the sources of MBTA revenue in Section 2 of this report, fares cover only a small proportion of the total cost of service. MBTA passengers are subsidized either directly by the MBTA or indirectly through taxpayer assistance.

6.5.1 Direct MBTA Subsidy Programs

The MBTA currently provides direct subsidies to several groups of users: the elderly, handicapped, students, and children. The level of subsidy and the regulation of law requiring it is provided in Table 6-6. The cost to the MBTA of providing the subsidy is also noted. These programs are described in the following paragraphs.

Elderly

Any person 65 or older, who is a resident of a community within the MBTA district, is eligible to ride the MBTA for free between 9:30 AM and 4:00 PM, Monday through Friday and for half fare at all other times. A senior citizen identification card, available from the MBTA, must be presented to the fare collector. State law (MGL, Chapter 161A, Section 5e) requires that half fares be offered to the elderly at all times. The MBTA Board of Directors and the MBTA Advisory Board approved the free-fare structure for off-peak travel. It should be noted that the Urban Mass Transportation Administration (UMTA) also requires that transit authorities receiving UMTA financial assistance make their facilities available to elderly for half the free fare during off-peak time periods.

The cost to the MBTA of providing free fares to the elderly is approximately $5.0 million more per year than if half fares were charged at all times.* If full fares were collected for all the elderly trips currently made, annual revenue would be approximately $12.3 million. The MBTA currently collects $2.7 million annually from its elderly riders, implying that the subsidy program is costing the MBTA $9.6 million in lost revenue alone. Additional costs are incurred in processing identification cards.

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*These figures assume no loss in riders.

	Fare	Citation	"Lost" Revenue Due to Subsidy Program
Student and Children	half fare	MGL Chapter 161A, Section 5e	$4.0 million
Elderly	half fare	MGL Chapter 161A, Section 5e	$9.6 million
Blind	free fare	MGL Chapter 6, Section 135	Not Available
Children 5 and Under	free fare	MGL Chapter 161A, Section 5e	Not Available
Handicapped - Off Peak	half fare	UMTA Regulation	Not Available
Elderly and Handicapped 9:30 to 4:00 PM (M-F)	free fare	Executive Order and Approval of MBTA Board of Directors and Advisory Board	$1.6 million*
THE RIDE	75 cents	UMTA Regulation - Minimum 2% of Section 5 money used on special programs - 1982 Operating Costs - $1,043,000 EST Trips - 80,000	$1.0 million

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*Difference between half fares and free fares.

Source: MBTA; estimate of "lost" revenue derived by CTPS.

MBTA SUBSIDY PROGRAMS

TABLE 6-6

Handicapped

Handicapped persons ride regularly scheduled MBTA service free between 9:30 and 4:00 on weekdays; pay full fares during the peak period, and half fares at all other times. UMTA regulations require that the MBTA offer half fare during off-peak times. Blind persons are carried free at all times as required by MGL, Chapter 6, Section 135.

In addition to the regularly scheduled service, a demand responsive service, called The Ride, is provided for a base fare of $.75. Operating costs of The Ride in 1982 are estimated at $1,043,000; revenue is expected to be $60,000.

Children and Students

Upper limits for children and student fares are set forth in MGL, Chapter 161A, Section 5e, which states that children between 5 and 11 pay half fare at all times, and children less than 5 ride free. Students aged 12 through 18 (through high school) pay half full-fare for school or school-related trips upon showing a valid student badge.

The MBTA subsidizes school trips by approximately $2.8 million per year. If children and student half fares were increased to full fares, the MBTA could take in an additional $4 million in increased revenue. There is no accurate way of determining the extent of travel by children under 5 years of age, and so the level of subsidy for this group alone cannot be estimated with any precision.

Other Subsidies

The MBTA also provides free access to the system to its employees. These riders, grouped with children less than 5, comprise approximately 3 percent of total daily riders. On an annual basis, this translates into a cost of $3.3 million. Fare evaders using the MBTA cost of MBTA approximately $440,000 per year in lost revenue.

6.5.2 Indirect Subsidy Programs

As described earlier, the MBTA receives financial operating assistance from several sources: the federal government, state government, and local cities and towns n the MBTA district. For 1980, the state's assistance amounted to 53 percent of total taxpayer assistance, local cities and towns paid 36 percent, and the federal government contributed approximately 11 percent (see Figure 2-12). In recent years, the state's share has been increasing both as a proportion and in absolute magnitude. All of these funds ultimately come from the taxpayer. The sources of taxes--whether the federal income tax, state income tax, gasoline tax, or local property tax--determine who, in effect, pays for the indirect subsidies to transit.

The question of who is subsidized by transit operations and the equity and efficiency implications of current operations have been studied extensively by several individuals and organizations.* The general conclusions have been that transit subsidies promote income redistribution from higher- to lower-income persons, but that changes could still be made in the pricing structure on transit systems to further enhance the benefits to low-income users. A review of the tax burden associated with the sources for the subsidies shows that the portion of assistance from the federal government is the most progressive (i.e., higher-income groups contribute a greater proportion of their income for the tax). In general, the federal income tax and the corporate taxes constitute the greatest portion of the federal tax revenue.

The state's share of the transit subsidy is paid for by taxes from various sources, among them are the state income tax, sales tax, gasoline tax, business tax, and cigarette tax. These taxes tend to be more regressive than the federal taxes. The greatest portion of the transit subsidy comes from these sources. The local contribution is from revenue generated by the local property tax, which is generally considered to be more regressive than the state or federal taxes.

Quantification of the "tax burden per household income", specific to the MBTA's subsidies and Metropolitan Boston population is outside the scope of this analysis, as is a detailed description of the incidence of the various local and state taxes.** A study of the transit tax payments per household using 1978 national data estimated that low-income households (less than $6,000) pay between $20 and $26 for transit taxes, while high-income households ($25,000+) pay between $147 to $185.*** Low-income households pay approximately 3 to 4 percent of the transit subsidies, whereas high-income households pay approximately 50 percent of the subsidies.***

In summary, both the direct and indirect subsidy programs of the MBTA have the net effect of providing an income redistribution from the higher- to lower-income households in the Boston area.

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*Two recent works used in this analysis are:

1) "Equity in Transit Finance, Distribution of Transit Subsidy Benefits, and Costs Among Income Classes," John Pucher, Journal of the American Planning Association, October 1981.
2) U.S. DOT, UMTA, R. Cervero, et al, "Efficiency and Equity Implications of Alternative Transit Fare Policies," September 1980.

**The reader is directed to an unpublished study (available at CTPS) by A. Palmere, "Alternatives for Financing the MBTA," April 1981, prepared for the League of Women Voters, for one set of Boston-specific data.

***Pucher, J., "Equity in Transit Finance," Journal of the American Planning Association, page 402.

6.6 SUMMARY OF SOCIOECONOMIC IMPACTS

This section has presented a review of the impacts of the recent fare increases on various groups of users. Since the implemented fare structure provides for free off-peak travel by elderly and handicapped persons, some of the adverse socioeconomic impacts associated with an increase in fares were mitigated. Increased fares typically affect the elderly more severly than other groups, as they tend to be living on fixed incomes and tend to be more dependent upon public transportation.

As expected, the fare increase affected low-income riders to a greater extent than higher-income groups. Depending upon the mode used, one individual from a low-income household could spend between 3 and 7 percent of his household income on the MBTA. This compares with 1 to 2 percent of the annual income for the average-income household. Fewer trips were lost from this group of users, as compared with other groups, as they tend to have fewer alternative means of travel and so they now comprise a larger proportion of daily ridership. Discretionary trips, such as shopping or social trips, experienced the greatest proportional loss, although the number of work trips declined by the greatest amount. Most of these work trips were made by commuters who had an automobile for their use. It is expected that almost one-third of the diverted discretionary trips are no longer made, whereas most other tirps are still made, but by using alternative modes.

Two measures are identified which could mitigate the socioeconomic impacts of the fare increase. One would be to provide a subsidy program to the MBTA's low-income riders. This type of program is described in Section 7. A second measure which could make the fare structure more equitable would provide a distance-based fare structure, possibly modified by time-of-day pricing, as well. This type of program has been addressed in the alternative section and would require a more automated fare collection system than currently is in place on the MBTA. A fare structure that varied according to distance traveled and reflected the relative cost of traveling at a specific time of day would more equitably charge users for the cost of carrying them than does the current zonal fare system. In this manner, fare changes could be more gradual and would tend to minimize the loss in riders and maximize the increase in revenue by assigning prices according to the service used.

This analysis has also developed a series of elasticities disaggregated by mode, time of day, user income level, and trip purpose specific to the MBTA. They are provided in Table 6-7 and could be used by the MBTA in the future to project the relative impacts of fare policy changes on various socioeconomic groups. In this manner, the MBTA might more closely gauge the revenue and ridership impacts of new fare policies.

	Rapid Transit	Combination	Surface
Aggregate Elasticity	-.24	-.28	-.32
Time Period			
- Off Peak	-.33	-.39	-.44
- Peak	-.14	-.17	-.19
Trip Purpose			
- Shop	-.27	-.32	-.36
- Work	-.17	-.19	-.22
Ridership Type			
- Choice	-.31	-.37	-.42
- Captive	-.15	-.18	-.20
Low Income	-.17	-.20	-.23
Age			
- 1 to 16 years	-.33	-.38	-.44
- 65+	-.14	-.17	-.19

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*Derived from changes observed for Boston between 1979 and 1981, and disaggregate factors reported in U. S. DOT report prepared by Ecosometrics.

DISAGGREGATE FARE ELASTICITES*

TABLE 6-7

In order to determine the social or economic impacts of fare policy and service changes for specific geographic areas within the MBTA district, more disaggregated data is necessary. The data from the 1978 MBTA Survey is not at a level of significance such that information on the socioeconomic characteristics of individual bus routes could be used. As 1980 census data becomes available, the base data used by the MBTA to evaluate the impacts of service changes on bus routes (e.g., density of low income or minority populations in communities through which the buses travel) should be updated. In this manner, the effects of bus and rail service changes to various socioeconomic groups of users could be more closely identified.

7.0 MITIGATING MEASURES

The option of increasing base fares for transit service is but one alternative to be used to raise additional revenue. The MBTA is implementing and further investigating several measures which would lessen the adverse impacts of the fare increases and service reductions on the public, as well as looking at alternatives to this action for future consideration. Both of these categories are described in the remainder of this section. In addition, for mitigating measures, information on the MBTA level of commitment and schedule of completion is provided.

The MBTA is actively implementing a number of measures which are designed to lessen the adverse impacts of the fare increases and service reductions on the public. These measures support the MBTA policy of increasing ridership while working to balance the overall financial burden among riders and public revenue sources. Furthermore, a listing of mitigating measures which will be accomplished and a schedule of completion is a required portion of the work scope.

Many of the mitigating measures suggested are at a secondary level of addressing services and operational issues which, in turn, affect the ability of the MBTA to control costs and increase ridership. Finally, a number of management issues addressed in the Management Practices Report are included here, although they are not discussed in detail in this report. These are presented to aid the reader in gaining a uniform understanding of the MBTA's scheduled commitment to mitigating the impacts of the fare changes.

7.1 SERVICE

7.1.1 Service Restoration

The increase in budget allocations for the Transportation Department of the MBTA allowed for the staged restoration of selected services during the fall of 1981 as well as additional restoration during 1982 and 1983.

The following is a summary of the service restoration/improvements made to restore ridership and provide better service:

Fall 1981

- Sunday evening bus service hours extended from 7:00 PM to 11:00 PM

Fall 1981 (cont.)

- Route 430A - peak hour service restored
- Route 97 - midday service restored
- Route 72 - midday service restored
- Route 458 - all-day service restored
- Headway (service frequency) Improvement or Trip Time or Routing adjustments on two dozen routes.

Winter 1982

- Headway Improvement or Trip Time or Routing adjustment on ten routes
- Route 130 - full midday service restored
- Route 212 - service Monday-Saturday restored

Spring 1982

- Downtown Crossing service restored
- Headway Improvement or Trip Time or Routing adjustments on ten routes
- Route 78 - service restored to Park Circle
- Route 90 - all-day service restored; route now services Assembly Square Mall
- Sunday evening service hours extended to 1:00 AM on all modes

Summer 1982

- Arborway Streetcar Service Restored
- Route 92 - service extended to serve Assembly Square

Fall 1982

- Route 44 - service extended to Franklin Park main gate
- Route 55 - service extended to Park Street Station
- Route 112A - service initiated
- Headway Improvements or Trip Time adjustments on more than two dozen routes

Winter 1983

- Evening service headway improvements on seven routes
- Route 3 - new route implemented
- Route 9 - all trips service Copley Square
- Route 16 - extended to service Forest Hills to UMASS during peak hours only
- Route 21 - Saturday service restored
- Route 47 - short-line operation between Dudley and Longwood Medical Area implemented
- Route 302 - Midday and Saturday service implemented
- Route 411 and 430A - combined to create new crosstown bus route
- Sunday service improved on 26 routes and restored on seven routes
- Headway Improvements or Trip Time adjustments on more than one dozen routes

Spring 1983

- Route 101 Sunday service extended to Malden Center
- Route 225 - AM peak trips routed via Shaw Street
- Route 350 - service to Burlington Mall initiated
- Headway Improvement or Trip Time or Routing adjustments on more than one dozen routes

7.1.2 Service Quality Improvements

Service quality improvements are being addressed through a multiplilcity of ongoing programs. Among these are equipment replacement and restoration, power distribution system restoration, signal system replacement, communications system expansion, and track replacement. Operational improvements include the provision of equipment maintenance and service evaluation systems.

Collectively, these improvements will reduce the number of incidents of system failure, and thereby increase reliability. Details of these programs with the MBTA's commitment to these programs follows:

A. Surface Traffic Improvements

Various efforts to improve the flow of buses and surface rail (Green Line) vehicles have been and are under consideration. In recent years, the number of bus stops have been reduced, and the remaining stops have been lengthened and clearly marked with signs. Additionally, bus lanes have been establilshed in downtown Boston as part of the Downtown Crossing Project. There also exists the bus/carpool or multiple-occupancy vehicle (MOV) lane on I-93 southbound, north of the interchange with Route 1.

On the surface rail lines (Green Line), the number of stops have been reduced, new passenger platforms constructed and intertrack fencing installed. These measures reduce the number of surface rail vehicle pedestrian conflicts and increase travel speeds. Work on Beacon Street and Huntington Avenue (Tunnel portal to Brigham Circle) and a part of Commonwealth Avenue have been completed. Improvements to the remainder of Commonwealth Avenue (Brighton to Warren Street) are being undertaken in 1983.

In conjunction with transit station construction, preferential treatment for buses is provided in the station area. Examples now in design or construction include the reconstruction of the bus tunnels at Harvard Station, exclusive bus lanes at Alewife and Davis Stations on the Red Line, and a busway at Ruggles Station on the Orange Line. A bus lane on Atlantic Avenue in Boston is proposed in conjunction with South Station area roadway improvements.

The City of Boston is near completion of design of a computerized signal system which will, in addition to providilng centralized signal control, provide for signal preemption for Green Line vehicles on Commonwealth Avenue and Huntington Avenue. The schedule for advancing this system to implementation is contingent upon availability of funds.

In conjunction with the Boston effort, the MBTA plans to install signal preemption equipment on the South Huntington/Centre Street segment of the Arborway Line.

In a study to consider replacement transit service in Boston's South End and Roxbury in the area of the Orange Line Elevated, alternatives of surface rail and bus in exclusive transit rights-of-way on city streets are being considered. Among these alternatives are surface rail on Washington and Tremont Streets between Dudley Street and South Cove, and buses on Washington Street, Dudley Street and Melnea Cass Boulevard.

The study effort and a decision to advance service improvements are scheduled for completion in 1984.

The MBTA has investigated the potential for additional bus lanes in the inner-city areas. Unfortunately, these investigations were unsuccessful in identifying bus lanes with high potential for implementation.

B. Equipment Replacement and Restoration

1. The bus replacement program consists of purchase of an average of approximately 100 buses each year to maintain an average fleet age of six years. Bids are being sought for procurement of 20 articulated buses in 1983.

   Also in 1983, consideration is being given to procurement of additional buses and/or rehabilitation of a portion of the existing fleet.

2. Acquisition of new cars for the Orange (120) and Blue (70) Lines was completed in 1982. In addition, the purchase of 58 Red Line cars is scheduled for bid in the fall of 1983. Vehicles will be scheduled for delivery in 1986.

3. Green Line LRVs are being slated for reconstruction, including general vehicle modifications to insure the durability of these vehicles.

4. A major upgrading of the existing facilities used to house and maintain the vehicle fleet is in progress. A replacement facility for the Riverside Carhouse is under construction. Renovation of Quincy and Lynn Bus Garages is scheduled to begin in 1983, as is minor rehabilitation of the Albany Street Garage.

C. Electrical Power Improvements

Several efforts are underway to modernize and upgrade the present capabilities of the MBTA's power system. These efforts include:

1. Conversion from the obsolete 25 hertz (Hz) power system to a centrally connected 60Hz system. As of mid-1983, two switching stations and seven power substations had been converted. Conversion of the remaining eight substations is scheduled for completion by the end of 1984.

2. Resectionalization of the AC/DC feeder cables between substations and tracks. Design of this program is scheduled for initiation in 1983-1984.

3. Power cable replacement of deteriorated cable ducts. This multi-year program is approximately 20% complete. The remainder of the program is scheduled for completion in 1987-1988.

D. Signals and Communication Improvements

A program has been advanced for the renewal or replacement of deteriorated or substandard signal equipment on the Red, Blue and Green Lines. The Red Line signal program is under construction and scheduled for completion in 1984. The Blue Line signal program is expected to begin in 1984 and the Green Line in 1987.

Included in this program are:

1. The installation of communication cable. This program is scheduled to proceed concurrently with signal installation.

2. The installation of an emergency telephone system. This program is also scheduled to proceed concurrently with signal installation.

3. Computer-aided bus radio system. Design funds are being sought in 1983. Installation is expected in 1985.

4. Completion of an MBTA/police radio system in the Authority's tunnels. This element is currently being installed and is scheduled for completion in 1984.

E. Track and Structural Improvements

A multi-year track renovation program in which all deteriorated and substandard track on the Green Line and the three rapid transit lines will be renewed or replaced. Major track improvements are proposed on the following lines:

1. The Blue Line (Airport to Wonderland). This project will be completed in 1983.

2. Green Line rights-of-way and track bed rehabilitation. The Riverside, Arborway and Beacon Street rights-of-way have been renovated in recent years. Commonwealth Avenue is being completed in 1983. The Green Line Central Subway track rehabilitation is scheduled to take place in phases over a number of years with the first phase (Haymarket Portal to Park) scheduled for initiation in 1984.

F. Station Renovation Projects

A number of station modifications and renovation projects have been proposed and are in various stages of planning and implementation. Among the projects currently being proposed are:

1. Columbia Station - Enlargement and renovation. A design consultant contract is currently being negotiated. Construction is scheduled for 1984-1985.

2. Kendall Square - Modernization, enlargement and improvements to the station and platform. Final design is scheduled for completion in 1983, with construction scheduled for 1984-1985.

3. Platform lengthening to accommodate six-car trains at Washington, Park Street (Red Line portion), South Station, Central Square, Broadway; and on the Blue Line, the Suffolk Downs Station. Suffolk Downs platform lengthening is scheduled for construction in 1983; Central, Park and Washington for 1984; and Broadway and South Station for 1985.

G. The Maintenance Program

A program to provide preventative maintenance and thus reduce operating costs, increase revenue and productivity, and also improve safety and service quality has been proposed. This program includes the provision of test equipment, shop tools, machinery, etc., as well as a sufficient quantity of spare replacement parts to maintain a high level of vehicle availability and regularly-scheduled inspections.

Collectively, the purpose of improvements such as these is to reduce the number of incidents of system failure and, thereby, improve service reliability.

For all passenger equipment, a formal program for vehicle inspection has been established. Adherence to the inspection program is reported on and monitored on a monthly basis. Normal regularly scheduled maintenance is performed in conjunction with the inspection program.

The MBTA is currently developing a system for programmed maintenance of rapid rail equipment. The system provides for scheduling and availability of replacement parts. This system is scheduled to be in operation by the end of 1983.

On the Green Line, the present focus is on undertaking a program to rehabilitate the existing Light Rail Vehicle fleet. It is felt that an effective preventive maintenance program should be considered after the fleet rehabilitation has been completed.

At the Cabot Bus Garage, vehicles are being assigned to operators and mechanics on a test basis. It is felt that continuous assignment of vehicles to the same employees may engender greater pride in maintaining equipment.

7.2 PLANNING

7.2.1 Service Planning Staff Increases

Management review of staff increases in the Service Planning Group as recommended by Touche-Ross is in process.

7.2.2 Revisions to the Service Committee

The MBTA Service Committee was reactivated in 1982. The Committee consists of representatives of Service Planning, Operations Planning, Schedules, Transportation (Surface Lines) and Customer Services. There are currently no plans to change the Committee.

7.2.3 Revision of 1977 Service Standards

Recommendations on revisions to the Service Standards are being developed through the MBTA's Bus Service Evaluation (SENTRY)

Project. A final report is scheduled for completion at the end of 1983.

7.2.4 Automation of Simple Service Planning Functions

A TRS-80 micro computer was installed early in 1983 for Service Planning staff use. Service Planning staff is currently participating in an APTA-UMTA Productivity Program to assist in the development of applications for the micro computer.

7.2.5 Improvement of the Planning Data Base

The Central Transportation Planning Staff is establishing a staff group to support the MBTA Service Planning Office in maintaining a comprehensive data base for service planning.

7.3 EFFICIENCY

7.3.1 Preventive Maintenance

The status of preventive maintenance programs is described in Section 3-F under Service.

7.3.2 Fuel Consumption Reviews

The Authority established an energy conservation program in mid-1979. This program includes, among other functions, the close monitoring of all energy use and cost for each of several hundred separate billing locations on both a monthly and annual basis. Since the monitoring is done manually and is extremely time consuming, efforts have been underway to computerize the process as part of the overall management information system being developed for the Operations Directorate by ATE Management and Service Company. This effort should be completed in 1984; however, this waiting period will not adversely affect current efforts in tracking energy use.

There are two basic objectivees for improving energy efficiency of the MBTA. The first and most important is modernization of the power supply which includes the conversion of the obsolete 25 hertz (Hz) power substations to 60 Hz power and the phasing out of MBTA self-generated 25 Hz power. The power supply system modernization effort is nearing completion and the results through 1982 indicate that the gross energy consumed in supplying the total electric power needs of the system has declined steadily from 3.6 billion British Thermal Units (BTUs) in 1978 to 2.63 billion BTUs in 1982, while the number of electric vehicle car miles increased from 15.9 million to 17.5 million.

The net result is a 51% improvement in gross energy consumed in supplying the total electric needs of the MBTA. The number of car miles operated per million BTUs of gross energy increased from 4.4 in 1978 to 6.658 in 1982. The gross energy decline from

3.6 billion BTUs in 1978 to 2.63 billion BTUs in 1982 represents a savings of 976,261 BTUs, which is the energy equivalent of 6.52 million gallons of residual (No.6) fuel oil.

The second basic energy conservation objective of the Authority is to enhance the energy efficiency of the operating system in terms of net energy input to the operating system per car mile operated. The net electric energy supplied to the operating system per car mile operated remained nearly constant, varying from a high of 14 kilowatt hours/car mile (KWH/CM) in 1981 to a low of 13 KWH/CM in 1982. The 13 KWN/CM in 1982 represents a significant improvement considering the introduction of a new fleet (190 rapid transit cars) on the Blue Line in 1979 and on the Orange Line in 1981, which consumed significantly more energy per car mile than the older equipment which was replaced.

The policy of the Authority is to continue efforts to monitor and improve the energy efficiency of the system by various measures which are economically sound. A major five-year program of capital improvements aimed at improving the energy efficiency of the rolling stock and fixed plant was developed in 1980 and is currently awaiting capital funding approval which is expected in 1984. A capital grant application was also submitted to the Urban Mass Transportation Administration (UMTA) requesting capital funding to begin converting the Green Line fleet of the Light Rail Vehicles to regenerate power and greatly improve the energy efficiency of the Green Line.

In addition to the reductions in electric system energy consumption, the amount of energy consumed by the fixed plant heating systems declined from 516,090 million BTUs in 1978 to 446,662 million BTUs in 1982, which is the equivalent of 500,000 gallons of No. 2 oil saved in 1982.

Automotive fuels have also declined from 7,586,603 gallons (diesel and gasoline) in 1978 to 6,538,510 gallons in 1982. (The 1 million gallon reduction is attributed to reduced bus mileage.)

7.4 MANAGEMENT

7.4.1 Management Rights

Effective use of the management rights provision of Chapter 581 has been an ongoing effort since the Federal Appeals Court affirmed the Acts' legalilty in October 1981. Appendix A-6 outlines those major actions that have been taken by the Authority through March 18, 1983. Additional actions under Chapter 581 will be considered on a continuing basis.

7.4.2 Management Information Systems

During 1982, the MIS Department was upgraded to the status of a Directorate, reflecting its importance. Also in 1982, a contract was signed with ATE Management and Service Company, Inc. to design a comprehensive MIS for the Authority's maintenance departments. This work is still proceeding.

7.4.3 Ridership Information Collection

The annual revenue/rider sampling program initiated in 1981 in support of the analysis of the fare increase was repeated in 1982 and is planned for continuation on an annual basis.

The Bus Service Evaluation Study (SENTRY) Report, which is scheduled for completion in late 1983, will identify methods for improved data collection. Alteration of data collection techniques will be reviewed at that time.

7.4.4 Performance Evaluating System

A system for measuring the performance of four major MBTA departments has been established. The four departments are: Transportation, Automotive Equipment, Rail Equipment and Engineering. The system is presently being refined to establish measures that are most helpful to Department Heads in monitoring and improving performance.

7.4.5 Management Practices Study

The Management Practices Study was completed on October 29, 1982.

7.4.6 Operator Work Rules

The MBTA's Transportation Department has established a Transportation Management Improvement Plan Task Force. The Task Force, which is comprised of Transportation officials, will work closely with the MBTA's Budget Office and others.

As implied by its name, the purpose of the Task Force is to develop a Transportation Management Improvement Plan. Among other things, the Task Force will address:

- Improved service delivery through reduction in dropped trips and improved appearance of employee uniforms.

- Improved management control through a "management by objectives" approach and utilizing improved Management Information Systems.

- Improved manpower utilization through hiring practices, training and development, work rules and assignment.

The Task Force's rcommendation, which will be made on an ongoing basis, will be advanced for further evaluation, policy action or implementation, as appropriate.

7.4.7 Productivity Measurement

In order to operate productively, the MBTA must obtain and use data on a regular basis which reflects the operating conditions.

A. Daily Service Report

The basic tool used for productivity measurement is the Daily Service Report. This report details the number of scheduled trips and the number of missed trips on a daily basis. These reports are summarized on a monthly basis in an effort to track service over time. Additionally, reports are prepared in specific areas such as customer complaints, overtime, and absenteeism to monitor service and achievement of management objectives.

B. Service Policy

Performance criteria for service (bus and surface rail) operations are described in the Service Policy for Surface Transportation.

The contents of the Service Policy are prefaced by a series of service goals and objectives towards which the MBTA strives. This is followed by a number of standards and guidelines for initial service design, operating performance standards, and economic, social, and environmental standards. This section describes the standards which guide evaluation of existing services and those for planning new or modified services. The service standards which have been adopted may be divided into service design guidelines (for new or modified services) and operating performance standards (for evaluating current services). A complete and detailed listing of these standards may be found in the MBTA Service Policy for Surface Public Transportation; however, examples of the standards are briefly shown below:

Examples of Service Design Guidelines include such items as:

a) Spatial Guidelines: Service provision based on population density by walking distance to transit services,

b) directness of services,

c) route deviations,

d) service frequency criteria, and

e) routing and market feasibility.

Examples of operating performance standards include:

a) Schedule adherence,

b) service dependability,

c) speed,

d) load factors, and

e) customer complaints.

Additionally, there are a number of economic and productivity criteria, e.g., passengers-per-hour and revenue-per-passenger mile, that measure economic viability of routes. The Service Policy establishes principles and a generalized procedure for service evaluation which will be effective in bettering the quality of service and the use of available evaluation resources. The role definitions and responsibilities of various departments of the MBTA are outlined and a flow chart has been established to make a more definitive procedure available for evaluating surface transit.

C. Data Collection

Consistent and accurate data collection to determine operating efficiency and ridership levels is a need now being recognized in large and small transit authorities in the U.S. and abroad. The MBTA's current practice of estimating ridership based on the average fare is not unique with respect to other transit authorities. In the absence of better data, this method has provided the MBTA with reliable enough information in the past. However, as operating costs rise in an inflationary spiral and government subsidies for transit decline, operating efficiency becomes the critical variable for all transit authorities.

A review of data collection techniques* in 1979 showed that many other transit authorities were shifting to more detailed data collection techniques, or at least investigating the possibility. Automatic passenger counting systems are being tested in several cities and the eventual application of high technology information systems management seems inevitable. Until automated evaluative processes evolve, other transit properties are using service standards or criteria as a measure of efficiency: schedule adherence, travel time, load factors, etc. These evaluation measures generally require a staff of checkers to record levels of service or ridership for evaluation. Montreal, for example, employs 49 checkers to collect and analyze data. In 1978, the budget for this program was $950,000. The Montreal system checkers count peak loads on all bus routes five times a year, and it is the only system to conduct regular origin-destination counts.

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*Bus Service Evaluation Procedures: A Review--Short-Range Transit Planning, UMTA-DOT, March 1979.

More exact measures of efficiency and ridership levels were achieved in Pittsburg and Minneapolis-St. Paul, where bus drivers on each route must record revenue and riderhsip. Winnipeg's transit authority has had drivers punch timeclocks at selected transit stations to evaluate headway times. These examples are the exception, however, as most systems use sampling techniques.

The most elaborate system used to evaluate service is that of the Southern California Rapid Transit District (SCRTD) which began using a 40-person checking program in 1975. By 1979, the $1 Million/year program evaluated service and ridership in comparison with accepted criteria. Recommendations from the evaluation resulted in a reduction of 11 million vehicle miles with little loss in ridership and $20 Million annually in savings.

The MBTA is seeking to employ some of the techniques used by SCRTD in its evaluation program, including a model for determining fare mix and ridership characteristics.

In order to measure performance against standards on a ongoing basis, an improved data base is necessary. The MBTA, through its "Ridership and Fare Mix Sampling Program," has established a means to improve and update its data base. Also included in the Authority's efforts to further augment its data collection capacities is the computer-based bus Service Evaluation/Transportation Reporting System (SENTRY), which will collect and summarize information regardilng ridership, revenue, service reliability, and customer complaints.

The objective of the ridership and fare mix sampling program is to define and estimate ridership using revenue data. Due to the new fare structure established in August of 1981 which has provisions for elderly and handicapped to ride free during designated hours, the previous estimate of average fare was no longer valid. This program was designed to quickly and inexpensively obtain reliable estimates pertaining to the number of riders on the MBTA, the fare mix, and the average fare being paid by these riders. Through a sample of riders on buses, trackless trolleys and at Green Line and rapid transit stations, a sample of November 1981 riders was conducted. The MBTA intends to conduct a similar sample in November 1982 and perhaps annually thereafter to observe ridership trends.

The computer-based bus evaluation system, known as SENTRY, is organized into three basic modules: 1) Marketing Data Base--information on ridership and revenue characteristics; 2) Transportation Reporting--field reports on the supply of bus service including service reliability and schedule adherence; and, 3) Complaints--MBTA records of consumer complaints utilized by SENTRY as a check on Transportation Reporting and to provide insights on route trends and variations.

It is expected that SENTRY will prove to be a most useful management tool to the Authority. Presently, the Authority collects a massive amount of bus service data. While some of the data is summarized, much of it is left in its original state and stored. The data report summaries which do reach management are often received too late to be acted upon. Management requires that bus service data be refined and summarized in a timely fashion if it is to be used as a basis for decision making.

In an effort to obtain better data, the MBTA is investigating a program to expand use of electronic pass readers to include surface vehicles. The Electronic Pass Reader Program is already in place at rapid transit stations and is being installed on a trial basis on selected bus routes.

In order to derive the full benefits from the Electronic Fare System, it must be extended beyond rapid transit to the entire surface fleet. This will allow the MBTA to achieve a true intermodal fare collection system, providing the Authority with reliable statistics, and the passenger with one ticket to transfer from mode to mode.

The surface equipment, as well as the entire program, will maintain flexibility to allow for technological developments and changes in fare levels. It is also designed to be compatible with rapid transit equipment for ease of maintenance and better inventory control, and to facilitate use of remote data collection and monitoring to give a total audit trail on a daily basis.

When fully implemented, the completed system will be composed of Data Storage units which will keep the daily information at each subway station and surface vehicle location, and would in turn be linked to a central processing unit using existing phone lines. The Authority's passenger traffic flow and revenue monitoring system will consist of utilizing contacts of solenoid (passenger flow monitoring) in the turnstiles and fare boxes which interface with the MBTA's own patented card readers. A data acquisition module will then transmit data to the central processing unit.

The Authority, after full installation and implementation, will have the means to accurately count all passengers and the ability to provide more accurate information for scheduling, safety and security. In the interim, the sampling techniques used to evaluate ridership levels are the best available methods. A significant portion of the annual operating budget, however, should be set aside for data collection and evaluation of ridership levels and operational efficiency. The SCRTD sets aside one-half of one percent of that Authority's operating cost for data collection and saved that figure many times over due to higher efficiency.

A summary of progress is being made in advancing efforts to improve productivity measurement on several fronts:

- Operations Performance
- Executive Personnel Evaluation
- Daily Service Reports and Service Tracking Reports
- MBTA Service Policy for Service Evaluation
- Bus Service Evaluation (SENTRY)

Performance measures have been developed for four Operating Departments: Transportation, Automotive Equipment, Rail Equipment and Engineering. Reports on the performance of these departments, which are produced monthly, are being refined.

The personnel evaluation procedure has been revised to identify manager objectives as a means of measuring productivity.

Daily service reports and service tracking reports provide basic information on service provided each day, such as number of scheduled trips made and reasons for not making scheduled trips.

The "Service Policy" establishes service criteria for surface transportation, while the Bus Service Evaluation Study consists of a review of those goals and establishment of a service performance measurement.

As each of these and other productivity measurement efforts advance, it is expected that they will become integrated into a comprehensive system. An important unifying element in the melding of these productivity measurement efforts is further development of the management-by-objectives based personnel evaluation efforts.

7.4.8 Manager Evaluation Process

The four major operating departments (Rail Equipment Maintenance, Automotive Equipment Maintenance, Engineering and Maintenance, and Transportation) have been working on developing performance indicators for their respective departments. Over the long-term, a review of these performance indicators can hopefully be included as part of the manager evaluation process. All four departments should have their performance indicators finalized by mid-1983. Integration into the manager information process can take place at that point, but no firm timetable has been established. Some departments, notably Automotive and Rail Equipment, are far enough along in the development of performance indicators so that integration into the manager evaluation process may begin earlier than mid-1983.

The personnel evaluation process for executives has been redesigned to establish performance measurement within the context of a management by objectives process. Top executives have attended one of four training sessions in implementation of the process.

In order to coincide with the MBTA's budget process, all executive performance evaluations have been rescheduled to take place in June of each year.

To assure that the manager evaluation process is followed correctly, the Personnel Department has been assigned responsibility for monitoring the process. The process also provides for progress reviews every calendar quarter and identification of management action for unsatisfactory performances, including further training, reassignment and termination.

Appendix A-8 includes a copy of the revised Executive Performance Appraisal Form, Annual Performance Planning Worksheet and Executive Salary Review Report. These documents have been developed for executive performance appraisals within a management by objectives process.

7.4.9 Maintenance Staff

The MBTA has hired 30 out of a scheduled 39 third class mechanics (automotive) to replace first and second class mechanics now performing fueling. The first and second class mechanics have been reassigned to do bus maintenance and repair. The final nine third class mechanics should be hired within the next several months.

In addition to this staff realignment, the MBTA is placing additional emphasis on preventive maintenance. The monthly Performance Indicators, started recently for Rail and Automotive Equipment Maintenance, give some sense of this emphasis with the inclusion of inspections as a specific goal.

Cleaning of buses and the Blue Line stations, Green Line stations, Red Line (Washington to Harvard), and Orange Line (Washington to Oak Grove) are being done through contracts. This portion of work was selected for contracting on a cost-saving basis.

8.0 MBTA EXPECTATIONS REGARDING FARES AND SERVICE FOR THE FUTURE

The four major areas which are expected to affect service and fare stability the most over the next decade are:

1. Limitations in public funding and changes in the availability of funding from various sources.

2. The continued shift in the location and density of residences and jobs within the Boston region and the resulting long-term service design.

3. The issues of operational improvements and related management rights for the MBTA.

4. Changes in the costs and supplies of fuels and other resources required for transit operations.

These factors will have a significant impact on fare policy, long-term service design, and operations, and thus will shape the future of fare levels and service provision.

These issues are discussed below:

- Public Funding and Fare Policy

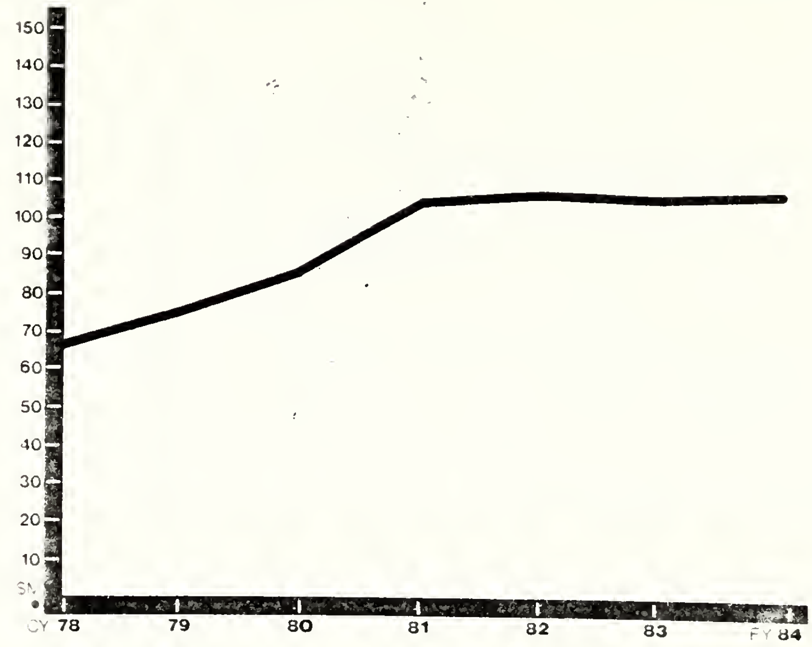
  A great deal of uncertainty exists concerning the future of federal support. Although Congress has not supported the move, current proposals at the federal level provide for the phased elimination of transit operating subsidies over the next three years. These subsidies currently provide approximately $20 million per year, which is the equivalent of approximately 9 percent of the MBTA's annual current expenses. Figure 8-1 shows the increase in State assistance and the decrease in federal funding.

  The line representing funds provided by the federal government are from the Urban Mass Transportation Administration (UMTA) and are designed to support the general operation, as opposed to the construction efforts of the MBTA. These funds help reduce the operating deficit of the Authority and therefore, help reduce the financial impact on the State, as well as on the cities and towns in the MBTA district.

  This assistance is projected at the same level for the near future as had existed in 1982. However, as stated earlier,

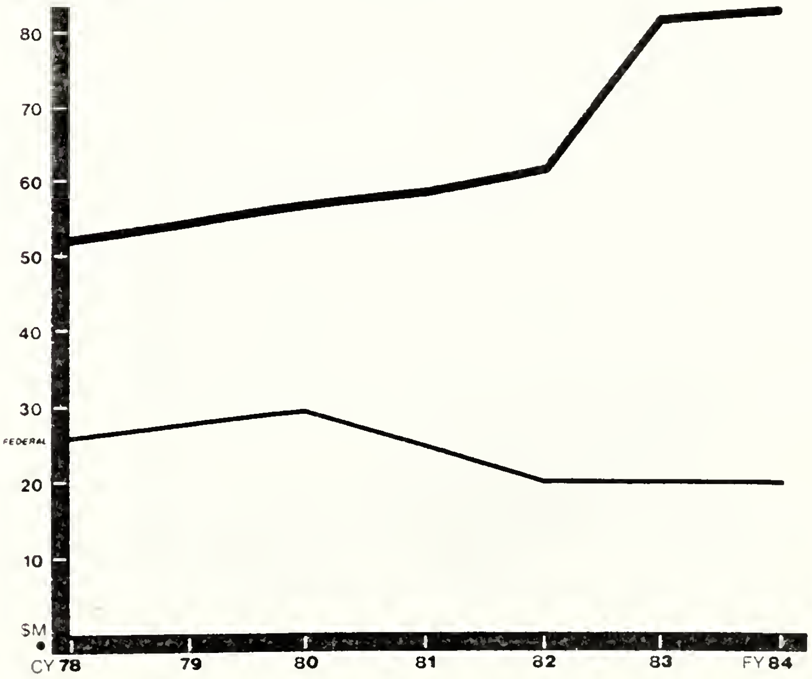
Total Income

Total income, after December of 1982 will increase 4 percent for calendar year 1983 and 6.7 percent over the next eighteen months



State and Federal Assistance

State assistance will grow in proportion to the fixed debt of the Authority



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substantial uncertainty exists concerning the future of this support. An initial proposal by the current federal administration was that these funds be eliminated by a one-third reduction each year beginning in 1981, resulting in no federal support of the operating deficit for the fourth year and thereafter.

Reimbursement is also made to the Authority by those localities which receive commuter rail service, and which are outside the 79 cities and towns which form the MBTA district. The reimbursement is provided to the outside districts by the federal government. There is substantial uncertainty concerning the future of these subsidies due to differences between the reductions proposed by federal Executive and Legislative branches. However, for 1983/FY84, the MBTA has projected a basically level funded amount.

Some increases in revenues from service are also expected to have some positive effects on the future fare picture. This income is derived from MBTA rapid transit, streetcar, and bus operations. 1982 Revenue (from transportation) had decreased to an annualized rate of approximately $88 million, caused by the reduction of fares in the spring of 1982. However, revenue from transportation is projected to increase by approximately 4.5% in 1983 and by approximately 6.7% over the 1983/FY84 period due to a projected increase in ridership.

In addition, commuter rail ridership had increased over 9% in 1982 and the Authority is projecting this trend to continue, which will enable a $200,000 reduction in this subsidy to be paid to the Boston and Maine Railroad (which is contracted to operate commuter rail services for the MBTA). However, as in the case of the MBTA, if fuel costs in the near future exceed presently projected levels, there will be insufficient funds to cover present levels of service.

Increases in ridership are being sought and appear to be headed in a positive direction and will draw additional revenue into the system. However, farebox revenue currently (1983) covers only 28% of total costs--up 7% since 1981.

Additionally, with Proposition 2½, local financial assistance is limited. Without a reversal of these policies, additional funding will need to come from other sources.

As a result, increased reliance on fare revenue as means of funding transit service can be anticipated. It is expected that as costs increase with inflation, fares will increase such that fare revenue provides for a greater percentage of total funding. However, the MBTA expects that although fare increases will occur in the future, they will occur so as to moderate fare impact on travel patterns.

In addition to increases in income, the MBTA can also greatly effect the net cost of service through reductions in operating costs and the institution of efficiency measures. These are discussed in a following section.

- Long-Term Service Design

As with operating subsidies, federal assistance for capital funding is expected to be far less in the next decade than in the 1970's. In the 1970's, a major infusion of capital funds was made to mass transit through the Interstate Transfer Provision of the Federal Highway Act. Interstate Transfer Funds available to the MBTA are fully committed to the Red Line Northwest and Orange Line Relocation projects. It is expected that remaining federal assistance for mass transit capital improvements will continue at the $70 million to $85 million a year level.

This trend in reduced capital funding is made more significant in the long-term when considering demographic trends in the region as a whole. The shift in population within the region during the 1970's contained a historically familiar pattern of heavy population outflows from the urban core to low-density communities located on the periphery. Population loss occurred in 44 communities in the region and was especially heavy in Boston, Chelsea, Everett, and Somerville. Employment location changes are most dramatic in the growth seen in the Northwestern and Southwestern communities; however, the Inner 128 subregion will gain the greatest absolute number of jobs. Appendix H provides a more detailed comparison of population and employment changes by subregion. In summary, the trends indicate that there will be shifts in transit demand in the coming decade (and beyond) which may not be matched by available resources.

To scale the MBTA's capital program to match the federal funding, the program's emphasis is expected to shift away from service expansion and toward plant rehabilitation and efficiency projects.

Currently anticipated service expansion will consist of the completion of the Red Line Northwest Extension from Harvard Square to Alewife Brook, the Orange Line Relocation -- South Cove to Forest Hills, and Quincy Adams Station. Other capital investments which will alter rail routes will not be service extension but rather will consist of service restoration of previous routes and relocation projects.

Proposed capital improvement projects are oriented toward reducing operating costs and serving dispersed travel markets. Projects include fringe parking facilities and priority treatment for surface transit vehicles. Such priority treatment would include bus lanes and preemptive traffic signals for surface rail vehicles and buses.

Additionally, with the increased dispersal of population and increased employment in an expanding regional market, emphasis on express bus and commuter rail service will likely increase, as will cross-town services around the Boston Core.

- Operational Costs and Efficiency Improvements

This area shows promise in offering some relief from decreases in general operating funds. With the management rights legislation (detailed in Appendix D), the application of some forms of modern technology, and more thorough data collection and management procedures, transit operations can become increasingly efficient. This elimination of inefficient work rules and more efficient utilization of resourses can gain significant savings which can directly reduce the need to turn to system users for increases in revenue. Major areas of improvement are:

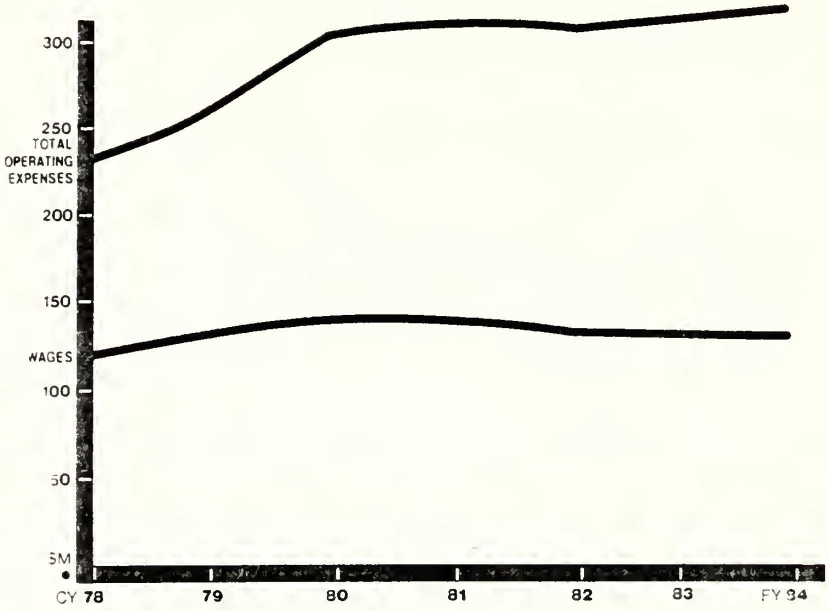
1. Work Rules - As a result of the passage of the Management Rights Act (Chapter 581 of the Acts of 1980), and its implementation on October 22, 1981, MBTA management has bee provided with the capability to operate the Authority in a manner consistent with desirable management prerogatives. The effects of this action can be seen in Figures 8-3 and 8-4. Being considered here are the salaries of all individuals working on daily operations of the MBTA. Separate from this and with its own budget is the Construction Directorate of the MBTA. This Directorate is funded by a split of approximately 80% federal support and 20% Authority bonding.

   As can be seen, wages for the Authority peaked in 1980. In 1981, the Authority dropped over 600 individuals from its payroll and over the next two years, will drop an additional 100 individuals from the 1981 level. There are no provisions for any union wage settlements projected here. Without wage increases, the wage line will decrease by approximately $1.8 million over 1983-1984. This decrease may be attributed principally to the integration of part-time workers into the Authority's work force.

   The transit industry, unlike other businesses, has peaks during mornings and evenings of each day, which mandated an available work day for many workers of 11 plus hours although they physically had to be on the property for only eight plus hours. The amount of time that operators were required to be available, but were not actually working, was paid at a "spread time" rate (10th to 11th at ½ salary, 11th plus hours at regular pay). Up to four

Total Operating Expenses/Wages

By the end of FY 84 wages will have decreased $9 million from 1980



Manpower (Operating)

Manpower at the Authority, by the end of FY 84, will be approximately 700 individuals lower than 1980.

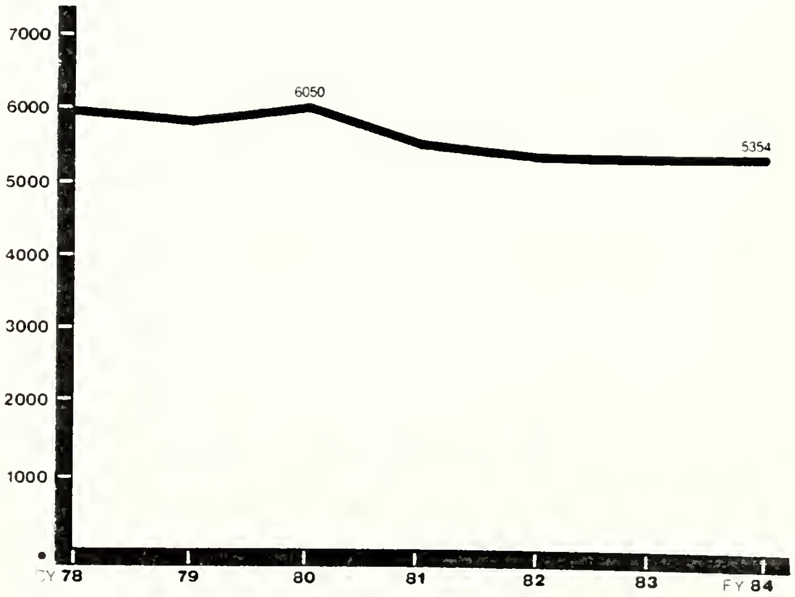


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TABLE
8-3,8-4

hundred part-time employees now will work the peak hour traffic at approximately 70% of the present full-time rates.

This type of change in allocating the work force has both immediate results as well as continuing benefit in reducing costs or in being able to provide upgraded service for equal costs.

2. Modern Equipment - The application of new equipment to operations can result in greater efficiency. Equipment used to extract revenue from fare boxes, for example, has resulted in reduced handling of cash and associated reductions in labor and increased control over revenue collection. Increased energy efficiency can also result from newer and well maintained equipment.

3. Contracting for Services - In areas which lend themselves to contracting with private parties rather than providing services with MBTA personnel, the MBTA has been exploring the possibility of contracting. As a result, the MBTA will be able to contract for services when work can be done more efficiently than with in-house staff.

4. Management Information Systems - Management Information Systems (MIS) provide for faster flow of information to permit management to make decisions resulting in the more efficient utilization of available resources. To date, the MBTA has implemented Accounts Payable and Materials systems. The Accounts Payable system permits the MBTA to make payments on bills in a more timely manner, thereby taking advantage of discounts for early payment and improving cash flow. Also, much of the billing documentation is being generated by computer, thereby reducing labor requirements.

   The Materials system provides for greater control of intentory, thereby resulting in reductions in the percentage of out of stock items and reduced inventory size and value. The reduced inventory saves money directly and the improved availability of materials reduces delays for the material user.

   Another system in the development phase is equipment maintenance. This system will enable management to track maintenance activity by employee, by vehicle, or by vehicle components to be replaced or repaired. This information can be used to track and identify equipment design and maintenance problems, evaluate personnel performance, and further control material inventories.

- Costs of Power and Utilities

In this category, a good deal of uncertainty exists for the long-term; however, short-term values may be projected. Reasonable estimates, based on what is known today about current and projected fuel utilization, indicate a rise during the near future however, energy efficiency.has been increasing as described in Appendix F-11 in detail.

Two basic components are contained within this graph:

- Power for running the system. This line has increased due to increases in the cost of electric power and by additional power needed for the running of Rapid Transit trains (non-revenue) on the Red Line Extension, Somerville.

- Fuel for buses and other equipment. This item is projected to increase by approximately $441,000. The increase is entirely due to estimates by the Authority that fuel costs will rise by 6.4% in the near future.

	1982 Price	Projected Average
Diesel Fuel	$.92 to $1.07 per gallon	$1.04 per gallon
Unleaded Gas	$.95 to $1.13 per gallon	$1.01 per gallon
Regular Gas	$.91 to $1.09 per gallon	$ .98 per gallon

In addition, with some more modern equipment (newer buses), and experimentation with fuels and fuel additives, the Authority expects to increase its average miles per gallon on buses (presently 3.6 miles per gallon). This is included in the total future values but can mitigate some future increases.